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THE FOLIOSE AND FRUTICOSE LICHENS OF COSTA RICA. I

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While there exists much literature on various groups of lichens from various parts of tropical America, at present I know of no recent work covering the whole area or that of any constituent country whereby the traveler may identify the lichens he meets, or the student in an herbarium of the temperate zone may readily determine any considerable portion of the miscellaneous material sent in by collectors. It is hoped that this work may furnish such a manual, although no one realizes better than I the huge amount of monographic work necessary before a book approaching completeness and accuracy can be published.

I first came under the spell of the rich flora of Costa Rica during a two-weeks visit in the summer of 1925 and at that time formed the resolution to spend my first sabbatical year in that country in the study of its fungus and lichen flora. During the subsequent years much material in addition to my own collections came to me for identification. Plans were matured and in early September, 1929, my family and I landed in Costa Rica and made our headquarters in San José, the capital of the country. In the latter part of September I was joined by Mr. W. Stephen Thomas, a student at Harvard, who accompanied me on most of the collecting trips until the middle of March. Mrs. Dodge also spent some time in the field and much is owed to her keen observation and helpful care of the collections. Even the small daughter, at the age of four, added a number of specimens

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not otherwise easily obtained, through her skill in climbing guayabos (*Psidium guajave* L.) which were too small and too brittle to be climbed by an adult. We left Costa Rica in June, 1930, and after a brief stay at the Farlow Herbarium to sort over material and give tentative determinations I took the more puzzling specimens to Europe where the months from August to December, 1930, were spent in the larger herbaria.

Very many persons and institutions have contributed to the success of this undertaking both at home and abroad, and to all I tender my most hearty thanks in grateful acknowledgment of their many kindnesses. For financial assistance, I am grateful to the John Simon Guggenheim Memorial Foundation which appointed me as a Fellow to Costa Rica for the year 1929-30 and to Europe from October to December, 1930; to the President and Fellows of Harvard College and to the Farlow Herbarium, for equipment, incidental expenses, and for an assistant in the field; to my colleague, Prof. Greenman, and former colleagues, Professors Ames, Barbour, and Thaxter, and to Mr. Paul C. Standley of the Field Museum, for excellent advice in planning my trip and for helpful letters of introduction. Members of the staff of the United Fruit Company were also very helpful both in planning the trip and placing the facilities of that great company at my disposal in Costa Rica, especially Dr. J. R. Johnston of the Boston office, and Messrs. Kress, Fuller, Crawford, Stübbe, and George Catt, the director of its Botanical Garden and Experiment Station at Siquirres, who accompanied me on several trips in that vicinity.

Among Costa Ricans, I am deeply indebted to the following for advice and hospitality, without which I should have been unable to cover so much territory so thoroughly in so little time: Bernado Yglesias Rodriguez, the Director of the Escuela Nacional de Agricultura, who placed the facilities of the botanical laboratory at my disposal and enabled me to spend three very profitable weeks at the ancestral Yglesias finca, Guayabillos, on the upper slopes of the western face of Irazú; to Anastasio Alfaro, formerly director of the Museo Nacional (and later to his successor, the late J. Fidel Tristan), who placed the facilities of the library and herbarium (Wercklé) of the institution at my dis-

posál and suggested the plan of my trip to Guanacaste, as well as contributing several specimens; to Dr. Alberto M. Brenes, the botanist at the Museo Nacional, who collected extensively for me in the vicinity of San Ramón, an interesting region which I did not have an opportunity to visit personally; to Ricardo Chavarría Flores, formerly city engineer of Cartago, who enabled me to collect extensively at his finca in the vicinity of Santiago de Cartago and the Rio Birrís; Juvenal Valerio Rodríguez, of the Instituto de Alajuela, who planned trips in the vicinity of Alajuela and to the Cerros de Zurquí; Otón Jiménez Luthmer, of the Botica Oriental, a well-known amateur botanist, who gave generously of his time in suggesting trips and making plans, although his business duties prevented his accompanying me in the field except for a short time on our trip to Guanacaste; to Ferdinand Nevermann, the coleopterist, for numerous pleasant collecting trips, including a three-weeks stay at fincas of which he is manager in Limón Province, and for much helpful information in connection with my large insect collections; to Ruben Torres Rojas, of Cartago, for specimens, although I did not have the pleasure of a personal contact with him during my short visits to Cartago; and to Charles H. Lankester, for helpful suggestions. Besides these who are more or less professionally interested in natural history, the following were generous in their hospitality and enabled me to visit regions which would have been otherwise quite inaccessible to the traveler: Gonzalo Volio and his son Carlos, Antonio Sobrado and his brothers, Carlos Collado, Fernando Castro, José Castro Araya, Antonio Gutiérrez, José Luis Sancho, Carlos Piedra and son, Alexander Ross and sons, Robert Hanckel, and H. J. Marks.

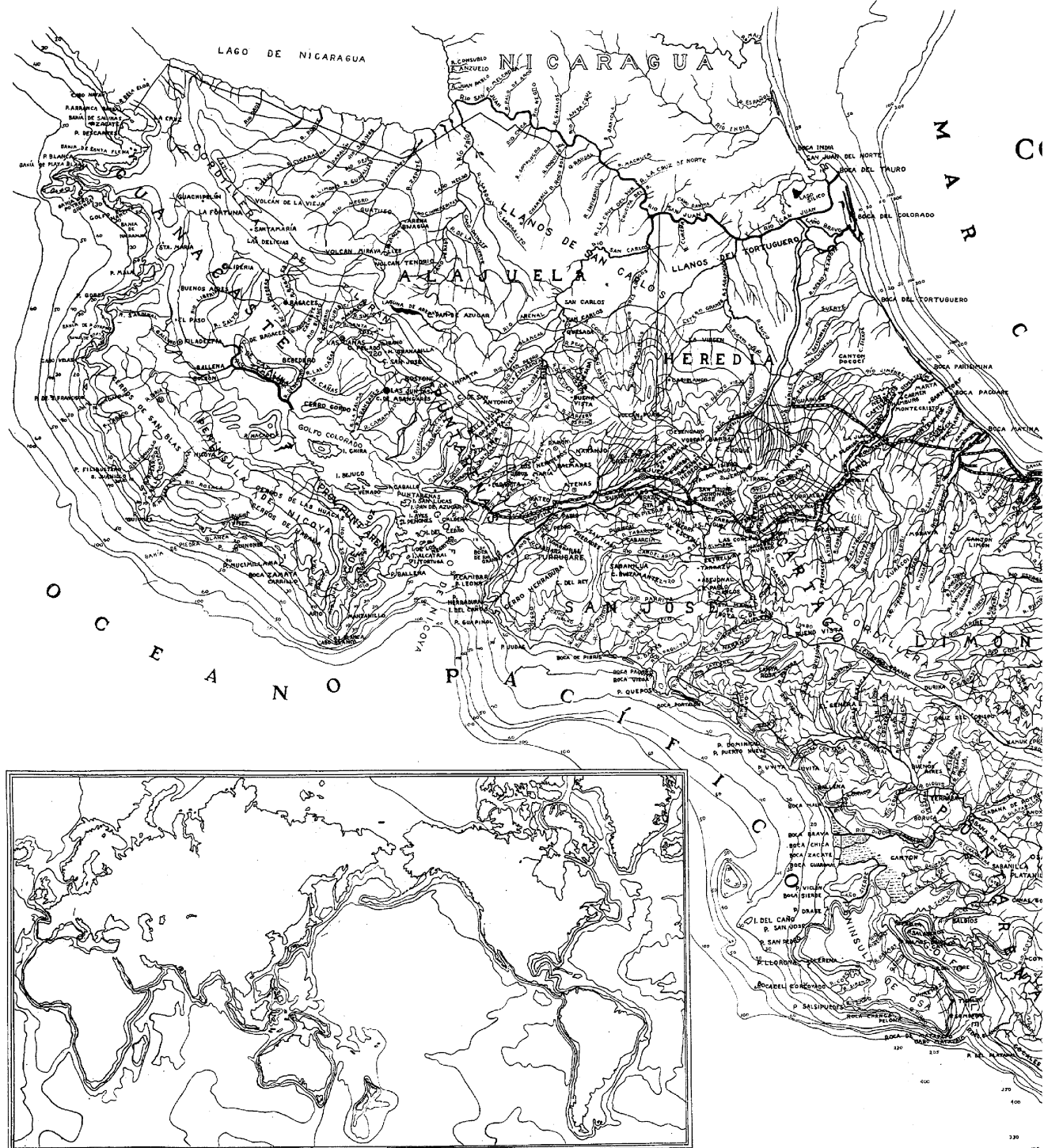
While in Europe I was indebted to the curators, acting curators, and staffs of the following institutions for permission to study the herbaria under their care: the Art Galleries of the Glasgow Corporation (Stirton Herbarium); British Museum of Natural History; Royal Botanic Gardens at Kew; Universitetets Botaniske Museum, Oslo; Botaniske Trädgård, Upsala; Riksmuseet, Stockholm; Botaniske Museum, København; K. Botanische Garten, Berlin-Dahlem; K. Botanische Museum, München; Conservatoire Botanique and Herbar Boissier of the Université

at Genève; and the Laboratoire de Cryptogamie at Paris, as well as the private herbarium of M. le docteur M. Bouly de Lesdain of Dunkerque. I am also indebted to the following lichenologists, whom I met during my trip, for helpful suggestions and criticism: Miss A. L. Smith, Bernt Lynge, Einar DuRietz, the late Karl Schulz-Korth, J. Motyka, and Ove Høeg. Since my return to America I have had access to or seen specimens from the following herbaria, for which I gratefully acknowledge my indebtedness to the curators: Farlow Herbarium of Harvard University, New York Botanical Garden, National Herbarium of the Smithsonian Institution, the Field Museum of Natural History, Chicago, the herbaria of the University of Michigan and of the Missouri Botanical Garden. I am also grateful to the Director of the Missouri Botanical Garden and to the Chancellor of Washington University for a leave of absence after the appointment to the staffs of those institutions, in order that I might complete certain studies in the Farlow Herbarium of Harvard University before I left that institution. Finally I wish to thank any others through whose hospitality and assistance this work has been made possible.

GEOGRAPHY

Topographically Costa Rica may be divided into four main phytogeographic regions: the Atlantic Coastal Plain, the Meseta Central, the Subalpine Region, and the Pacific Coastal Region, the latter less well known and less homogeneous.

The Atlantic Coastal Plain is characterized by its gentle slope from the sandy beaches up to about 100 m. or even higher in the poorly known Llanos de Santa Clara and in the Sarapiquí, San Carlos and Río Frío valleys. The beaches are interrupted only by shallow harbors at Cahuita, Limón, and Moin, the first being protected by a coral reef, the two latter being partially protected by the small island Uvita, now used as a quarantine station for Puerto Limón. Several large rivers rising in the highlands cross this plain and during their flood states overflow, forming spectacular anastomosing channels which leave small pools in the dry season. Most of the river mouths are closed by shifting bars which hinder or prevent the use of the rivers for



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BOCA RATON

Map of the Limón area showing the Limón River and surrounding regions. The map includes labels for 'BANDA DE AN...', 'LIMÓN', and 'PLUVITA'.

BOCA BANANG

BOCA DE LA ESTRELLA

COCEB
P. MANZANILLO

BOCAS DE LA PIRANTESA

CRISTÓBAL

DE ALA PL. BRANDO C. ROVALDO C. BANDO CHANGENI

A map of the area around San Juan, showing the location of the 'PROGRESO' station and the 'EUALACA' station. The map includes labels for 'SAN JUAN', 'PROGRESO', 'EUALACA', and 'SECA'.

A map showing the location of the study area (I. PERDA) relative to the city of MARANO. The map includes a scale bar from 0 to 10 km and a north arrow. The study area is marked with a black dot and labeled 'I. PERDA'. The city of MARANO is labeled 'MARANO'.



shipping. Just back of the beach there is an almost continuous series of lagoons, which may be dredged and may be used for transport of the farm produce to the railroads and ports. These lagoons extend most of the way from San Juan del Norte to Limón.

The soil is quite fertile where drainage is sufficient and much of the forest has been cleared for agricultural purposes, in the Llanos de Sta. Clara and Limón. The rainfall is heavy and quite evenly distributed, although somewhat less during January, February, and March, the so-called dry season (*verano*). During most of the year the sun shines until about noon, then showers may be expected for either a short time or for the rest of the afternoon. The nights are usually clear and cool.

During the colonial era there was very little permanent settlement of this region although many attempts were made. Some cacao plantations were developed at Matina, and their product taken overland via Cartago to Honduras and Guatemala or quietly sold to the English pirates and smugglers who frequently entered the mouth of the Matina River for this purpose. With the advent of the Northern Railroad in 1870–1890 the banana industry spread rapidly over most of the available land from the Parismina to the Estrella River valleys and up the Sixaola from Bocas del Toro. When the banana wilt or Panama disease (*Fusarium cubense* E. F. Smith) and increasing soil exhaustion began to threaten this industry, coconuts, pineapples, and cacao were extensively planted in suitable localities. Coconuts were a prompt and complete failure owing to bud rot and other factors, although they still furnish enough for local consumption. Pineapple cultivation has recently been abandoned for economic reasons, although the product was much superior to that of Hawaii. Cacao cultivation has been only partially successful owing to high labor costs. Recently much land has been practically abandoned and is gradually returning to second-growth forests. While small plantations of forest trees, as *Hevea*, *Ochroma*, etc., are still in an experimental stage, they seem to be successful botanically but owing to the high cost of labor they are still doubtful economically. Maize is sometimes grown on the Llanos de Santa Clara.

The Atlantic Coastal Plain penetrates far inland in the Tortuguero, Sarapiquí, San Carlos and Río Frío systems, but since I have not had an opportunity to examine them personally and have seen very few specimens from them it is impossible to discuss them further. Before the railroad was built the Río Sarapiquí was the main route from San José to the Atlantic, and a few villages still remain. There are a few scattered settlements on the Río San Carlos and Río Frío, as may be seen from the relations of Thiel and Cespedes, but except for a few specimens by Pittier from the upper Sarapiquí Valley and from the vicinity of San Rafael on the R. San Carlos, I know of no lichen collections from this region.

The Atlantic Transition Zone from 100 to 900 m. is evident mostly in narrow river valleys, the only botanically well-known portions being the southeastern portion of the Llanos de Santa Clara around Guápiles, formerly an important farm of the United Fruit Company used for their earlier experimental plantings of forest trees, and the valley of the Reventazón.

In the valley of the Reventazón, tertiary sedimentary rocks are evident in the cañons and railway cuts. The slopes are very steep, due to the great erosion caused by the heavy rainfall which is about the same as that of the Coastal Plain. Bananas and coffee form the principal crops in the broader side valleys, the banana being comparatively short-lived but much used as a shade for the coffee. Since this development is comparatively recent, it still remains to be seen whether this is a permanent stage or a temporary phase in the agricultural development of the region. Formerly sugar cane was extensively cultivated in this region and considerable areas remain in Juan Viñas and Santiago de Cartago. Pineapples are grown for the domestic markets near Turrialba and to a less extent in some other places. Owing to the rapid erosion it seems doubtful whether much of the land which has been cleared on such steep slopes can remain permanently in cultivation. There are available a few collections from Angostura near Turrialba by Polakowsky and my own from the beautiful valley of the Río Pejivalle near the United Fruit Company's farm of that name, as well as the even more extensive ones from Santiago de Cartago and occasional specimens from

Juan Viñas (Naranjo) by Ørsted and scattered numbers by Pittier.

On the practically inaccessible slopes and in the valleys where transportation is too costly to make farms economically profitable yet, some forests are still to be found. These still resemble those of the Atlantic Coastal Plain with their abundant epiphytes, bromeliads being conspicuous, especially *Tillandsia usneoides*. There are many small areas among the hills where fogs keep the humidity much higher than in neighboring areas. These are quite evident by the abundance of the long pendulous species of *Usnea* which replace *Tillandsia usneoides* as a prominent feature of the landscape. Species of *Leptogium*, *Parmelia*, *Anaptychia*, and mosses are also very abundant. Cladonias begin to appear and replace the similarly colored moss of the lower elevations. In the top of the forest trees and in the isolated trees of the potrero (pasture), crustose species are abundant. In the lower levels of the forest, lichens are rarer and usually sterile, perhaps due to the small amount of light. Trees whose bark scales off rapidly, such as the guayabo (*Psidium guajave* L.), are rarely found to have lichens, except for a few fruticose species of *Ramalina* and *Usnea*. *Nephroma* was found in one of these *Usnea-Tillandsia* zones on an exposed "knife-edge" protruding into the cañon of the Reventazón near Santiago de Cartago.

The Meseta Central, occupying the huge central valley between the Cordillera Central and the Cordillera de Talamanca, consists of long gentle slopes between 1000 and 1700 m. cut by deep river gorges. The pass of Ochomogo and the Cerro de Carpintera divide this meseta into two portions, the eastern valley of Guarco, comprising the upper portion of the valley of the Reventazón and its tributaries, and the western valley of San José, comprising the upper part of the valley of the Río Grande de Tarcoles and its tributaries. The valley of Guarco is bounded on the north by the upper slopes of the volcanoes Irazú and Turrialba and on the south by the continental divide in the Cordillera de Talamanca. Most of the large tributaries enter from the south and are not explored fully from a geographical standpoint. I have seen lichen collections from the valley of the Río Navarro and the

lower part of the Orosí. The Río Grande is by far the largest and longest of the tributaries but its flora is wholly unknown to me. Coffee is the principal crop though considerable amounts of garden vegetables, especially chayote and yuca, are raised to supply not only the local markets but also the demands of the Atlantic Coastal Plain. Cartago, the colonial capital, is the only city but there are numerous small towns. The collections of C. Wercklé, "near Cartago 1200-1500 m.," in San José and Berlin, seem to be from the region about Aguacaliente and the lower slopes of the Cerro de Carpintera, judging from species represented.

The valley of San José is bounded on the north by the continental divide of the western portion of the Cordillera Central, the volcano Poás, and Barba with its lesser peaks, the Cerros de las Caricias, Las Lajas, and Zurquí, on the east by Irazú and the Cerro de Carpintera, on the south by the Cerros de Escasú and Piedra Blanca, on the west by the Cerros de Aguacate. In the valley of San José the slopes descend gently to about 650 m. This valley is much drier than the Guarco with a longer dry season from December to April and less rain in the other months. The winds are strong, especially in the dry season. Practically the whole region has been denuded of forests, partly in the interests of agriculture and partly owing to the fiendish glee of the inhabitants who deliberately set fires to the dry grass on windy days in order to watch it burn. By the end of the dry season practically the whole valley outside the cafetales and cane fields is black from the charred remains of grass fires.

The underlying rock of both valleys is largely volcanic, while the soil above is largely of aeolian origin from the volcanic dust which is still being regularly emitted from Irazú and occasionally from Poás. In some places fields of volcanic boulders exist in such profusion that they make agriculture as difficult as do the glacial boulders in parts of New England. The greater portion of both valleys is devoted to coffee growing, with sugar cane and upland rice in the lower levels. Formerly considerable excellent tobacco was grown but this crop has practically disappeared. The cities of Alajuela, Heredia, and San José, and many important towns are located in this valley.

Crustose lichens are abundant in the cafetales both on the coffee and its shade, but practically no attempt was made to collect them since the thalli are mostly young and sterile and we hesitated to injure the trees by removing portions of bark. The living fence posts, mostly species of *Erythrina* (poró), were utilized, however, since they are regularly and heavily pruned back. These yielded most of the crustose species from this area. Another fruitful source was the roadside bank. These banks are caused by erosion and by cutting down with spades to secure material to fill in holes in the road. The depth of a road in most places is proportional to the slope and to its age, a recently laid-out road having only slight banks while an old road often has vertical sides rising 15–30 feet above the wheel tracks. These banks have a wealth of lichens, bryophytes, and fungi during the rainy season (invierno) but usually dry out, except in occasional moist shady spots, during the dry season. Consequently most of the species are annuals and disappear quite completely during the dry season. These banks are even more conspicuous and important in the Subalpine Region.

The Subalpine Region probably includes most of the land in Costa Rica above 1700 m., but is known botanically only on the Cordillera Central and the northernmost mountains of the Cordillera de Talamanca as far as the Cerro de las Vueltas. Poás, Irazú, and Turrialba are largely cleared on their southern slopes and used for dairy farms. Barba is still largely wooded and inaccessible, but Standley and Maxon have explored the slopes of the lower peaks of the Cerros de las Caricias, las Lajas, and Zurquí. I also had the opportunity to spend two days on the lower slopes of Zurquí. Standley and J. Valerio secured an extensive series of lichens from Cerro de las Vueltas and neighboring peaks within reach of Santa María de Dota, in 1925–6. Various collectors have brought back small series of specimens from Poás. Standley in 1924 and I in 1929 collected on the south slope of Turrialba for a short period, and I spent about three weeks at Guayabillos on the west slope of Irazú, as well as climbing to the crater twice from the south side. Ever since the time of Ørsted many collectors have brought in a few specimens from Irazú. The alpine and subalpine areas of Irazú

are much less rich than the other mountains probably because of the constant dust. On my last ascent I did not find even a sterile thallus above 3000 m., while Ørsted reports lichens from the summit. Botanically this Subalpine Region is the most interesting, as it has a high percentage of Colombian and other South American species, as well as most of the endemic species.

The Pacific Coastal flora is too poorly known to classify into geographical divisions. I have been told by lumbermen that there are many interesting local distributions of the forest trees but these observations are too fragmentary for generalizations. For present purposes we may subdivide into the province of Guanacaste the peninsula of Nicoya, the great river valleys of the R. Naranjo, R. General, and R. Grande de Térraba or Diquís, and the Peninsula of Osa. Of these regions I have personally visited only the first and the last. The peninsula of Nicoya has not been explored at all as far as concerns lichens, while our knowledge of the great river valleys is due solely to two journeys by Pittier, Biolley, and Tonduz, in January and February, 1891, and by Tonduz from October 18, 1891, to April 17, 1892 (see p. 388).

The province of Guanacaste consists of a low coast range penetrated by the Bahías de Culebra and de Salinas, a broad valley of the R. Tempisque about 40 km. wide and 60 km. long, rising gently from sea level to about 200 m. and sloping again gently to the Lago de Nicaragua, with Liberia, the provincial capital, at its center, and the west slope of the Cordillera de Tilarán (or de Guanacaste) on its east. Ørsted crossed the plain from the Tempisque to the Bahía de Salinas and explored the region of R. Sapoá and the coast, but I have seen no lichens from this region. Pittier collected along the shore of the Bahía de Salinas and may have penetrated the low coast range. Otherwise it is unknown as far as lichens are concerned. The plain of the Tempisque is used for grazing with some sugar cane grown in the southwest part in the vicinity of El Paso. The underlying rock and soil in Liberia is white cascajo, a soft pumice laid down in water and hence somewhat stratified. Further south there are clay deposits. Rainfall is high during the rainy season but the dry season is hot and dusty, unofficial temperature in the

shade rising as high as 108°F. in the hottest part of the day and correspondingly cool at night. Wind velocities are high where the trade winds sweep through the passes between the volcanoes in the first half of the dry season, so that most of the perennial vegetation is that of the arid regions and may account for the similarity of the flora with that of Nicaragua and the north. Here grass fires are even more frequent in proportion to the population and more destructive, hence the region is seldom visited by botanists; in fact I have failed to find any collections from this region or any mention of it in botanical works. In 1930 I was able to spend about two weeks in the vicinity of Liberia.

The western slopes of the Cordillera de Tilarán are used for grazing, with small cafetales located in sheltered, moister areas. The vegetation does not appear much different from the plain of the Tempisque, especially on the exposed slopes, but in the sheltered ravines more delicate types survive. This region has not been visited by botanists to any great extent, although Standley and J. Valerio collected in the vicinity of Tilarán in 1926, and Valerio probably made studies of the local flora of Tilarán while he was stationed there as a teacher some years ago. Besides a week in Tilarán I spent about a week at 700 m. on the slopes of Santamaría, the next peak south of La Vieja, and a week at La Granadilla on the plateau between the R. de las Cañas and the R. San José which culminates at 960 m. in the Cerro de San José.

In Santamaría and Tilarán, even during the dry season, much of the time the weather was characterized by mists and high winds and much rain, while a short distance lower and to the west there was neither mist nor rain. However, the brief intervals of hot sun are sufficient to keep the xerophytic vegetation on the wind-swept prairie, while the sheltered ravines and shaded hillsides have mesophytic types. At Tilarán we crossed the continental divide into the headwaters of the Río Frío system with a change in vegetation even more striking than in the pass at Ochomogo in the Meseta Central.

The Cerro de San José rises sharply above the surrounding peaks to 960 m., somewhat higher than the near-by peaks of the

continental divide. It seems to be composed of stratified sedimentary rock sloping 40° S, 70° W. To the west rises the lower exploded crater of Cerro Pelado, while to the east lie the lower peaks which form the junction of the Cordillera de Tilarán and the Cordillera Central. Though the region is considerably drier than the same elevations on the Cordillera de Tilarán, yet it maintains a luxuriant forest vegetation where it has not been cleared for potreros. Being an isolated wind-swept and fire-swept peak, the vegetation of the summit has a stunted, subalpine appearance. The Hacienda Granadilla on the plateau between the Río de las Cañas and the Río de San José at about 500–600 m. furnished much interesting material, especially as we were fortunate in finding two huge pochotes (? *Bombax elliptica* HBK.) which had blown over so recently that the crustose lichens were still fresh and the clusters of orchids and bromeliads were still in bloom. These furnished about the only collections to show the flora of the tree tops in Guanacaste.

The region between the Cerro de San José and Puntarenas has not been visited by botanists to my knowledge, although it is quite accessible on account of the Abangares and other gold mines which have been exploited more or less continually since colonial times. Since the region is of a different geological formation it would probably well repay investigation, as would also the calcareous Santa Catalina range between the R. Tempisque and R. Bebedero at the head of the Gulf of Nicoya.

The peninsula of Osa between Golfo Dulce and the Pacific consists of low mountain ranges, probably of sedimentary rock; at least such were the outcrops observed along the shore and in the gorge of the Quebrada de la Laja, a tributary of the Río Nuevo. G. Cufodontis, of the Austrian expedition of 1930, visited the region in the immediate vicinity of Puerto Jiménez (Santo Domingo, on many old maps and charts, on the small bay just above Puntarenitas). Two weeks later I visited the same region, also the Hacienda Sándalo between the Tigre and Terrones Rivers (marked Necki on the charts). The coastal plain about a mile wide slopes gradually from the beach to about 30 m. and then more steeply up the spurs of the range which follows the west coast of the Golfo Dulce. The forest is still virgin in most

places and consists of a rather open palm and hardwood forest characteristic of well-drained areas. The coast between the tide levels has a characteristic mangrove swamp. Mr. Dunlap, of the United Fruit Company, visited this region a few years ago but I have not learned of any specimens taken. Mr. H. J. Marks, the proprietor of the Hacienda Sándalo, has sent a few specimens of wood and herbarium specimens of forest trees to Prof. S. J. Record of Yale University.

Practically nothing is known of the flora of the islands off the west coast. The only one which has been visited by botanists, Isla Coco, has so far yielded very few foliose or fruticose species. Dr. H. K. Svenson, botanist of the Astor expedition, one of the latest to visit the island, describes it as follows: "The lichen flora must be very inconspicuous; I did not go out of my way to look for lichens but if any large forms had been in my path, I believe I would have picked them up. Cocos Island is entirely covered by a rank vegetation which the sunlight rarely penetrates." So far the only species reported are one *Leptogium* and two *Parmelias*, all wide-ranging species of the tropical lowlands.

BOTANICAL EXPLORATION

Of early botanical exploration in Costa Rica the little that is known apparently indicates that few or no cryptogams were collected. Martín Sessé and José Mariano Mociño probably visited the Pacific Coast between 1795 and 1804. The "Sulfur," with George Barclay as botanist, entered the Golfo de Nicoya about 1840 and about the same time Emmanuel Friedrichstahl visited a portion of Nicaragua and Costa Rica though his collections were not carefully labeled as to locality, all the sheets being marked Guatemala.

Between 1845 and 1851, the "Herald" probably visited Pedregal, the harbor for David, Panamá, as Seemann the botanist brought back from Boquete and the neighboring volcano of Chiriquí, lichens which were studied by Churchill Babington and published by Seemann (1852-1857). These specimens are in Babington's herbarium at Cambridge University and in the Royal Botanic Gardens at Kew.

The first to make extensive collections was Anders Sandøe

Ørsted (1816–1872), to whom we owe the first elaborate accounts of the natural history of Costa Rica. For details of his travels and lists of plants collected at various places, see Ørsted (1848, 1851, 1863), Hemsley (1878–1888), and Durand & Pittier (1891). He entered the country at Puntarenas, passing over the old carretera which ascended the Cerros de Aguacate thence via Alajuela to San José, where he made his headquarters for some time. From this point he visited C. Escazú and Pacaca, penetrating to the mountains of Jarís to the south. He also visited Candelaria, probably in the vicinity of Tablazo, judging from the list of plants he collected in that locality. In May, 1847, he explored Poás and Barba. Earlier in that year he had spent some time studying the volcano Irazú, making his headquarters in Cartago. From this point he visited Aguacaliente and Ujarrás (probably the valley below the modern Paraíso), then made the very difficult trip to Moin over the old trail now largely abandoned, passing Cervantes, Río Birrís, and Quebrada Honda to Naranjo (the modern Juan Viñas), thence to Turrialba, keeping along the shelf of land above the lake near Tunnel Camp, Bonilla, etc. to the customs house on the R. Reventazón (probably below the present La Junta) where he crossed the Reventazón in canoes and proceeded along the coastal plain to Moin.

Another long trip was his visit to Guanacaste and adjacent Nicaragua, the details of which were published in 1848 from a letter he had sent home. He does not state in what year this trip was undertaken, but since the mention that Puntarenas was then a free port (this having been decreed in 1847) and since he was visiting volcanoes in February and May, 1847, it is probable that he made the journey in 1848. He was persuaded by government officials to explore a possible route for an inter-oceanic canal between the Lago de Nicaragua and the Pacific. The party, headed by Francisco Gutierrez, left San José on February 17 for Puntarenas, where they took a huge canoe up the Gulf of Nicoya and thence up the Río Tempisque. On March 8 they set out with a pack train from Santa Rosa for the Hacienda Sapoá just above the junction with R. Bolaños. Thence they visited H. Las Animas above the junction with the R. Guachepelín, ascending that valley and descending the R. Tortuga,

the next river east of the R. Sapoá. Ørsted may have visited some of the islands in the Lago de Nicaragua before he ascended the Río Sapoá to the junction of the Sansapote and overland to the H. Sapoá. Another trip was taken to the Golfo de Bolaños, thence over the height of land and down the Sansapote to its junction with the Sapoá.

Ørsted also visited San Juan del Norte (Greytown), crossing the pass between Barba and Irazú at La Palma and descending along the Río Sucio and the R. Sarapiquí. It is not known whether he sailed from San Juan del Norte or from Puntarenas, which was frequently visited by Danish vessels at that period, thirteen having called there in 1853.

Warszewicz, coming from Guatemala via El Salvador and Nicaragua, is said to have met Ørsted in Nicaragua before reaching Costa Rica via the R. Sarapiquí. He evidently visited Irazú and Turrialba, but I have seen no lichens from his collections.

Ørsted's huge collections are to be found in Kjøbenhavn where their study has only recently been completed. They were distributed about 1931. The fungi were sent to Elias Magnus Fries at Upsala and were published promptly by him in 1851, portions of the collections being found in both Kjøbenhavn and Upsala. The lichens were sent to Th. M. Fries but only a single number, *Stereocaulon obesum* Th. M. Fr., was published. Some have since been named and inserted in the herbarium at Upsala. Through the kindness of Professor N. Svedelius, the remaining unnamed specimens were turned over to me for study and are reported in this work. At present none of Ørsted's lichens are at Kjøbenhavn but it is probable that a complete set of duplicates will eventually be deposited in that herbarium.

Ørsted was soon followed in Costa Rica by a number of naturalists who have left us long accounts of geology and natural history. Many resided in Costa Rica for several years, but few appear to have collected lichens.

During his visit, Polakowsky collected a few specimens studied by Nylander (1876) and apparently distributed quite widely, as I have seen a complete set in Berlin and scattered numbers in other herbaria.

A new era for Costa Rican natural history began with the establishment in 1887 of the Instituto Fisico-geografico Nacional de Costa Rica, with Henri Pittier as its first director. Due to his enthusiastic explorations and those of his fellow botanist, Tonduz, a large herbarium was assembled in San José and materials were sent to many foreign collaborators for study, resulting in the publication of Durand and Pittier (1891-1901). The lichens which were studied by Müller Argau were largely from two extensive expeditions to the southwestern portion of the country and scattered numbers collected by others in various parts of the country. Pittier (1891) described these expeditions in detail. As these collections will be frequently mentioned I have thought it wise to include an abstract of their itinerary.

On January 15, the first expedition reached San Marcos de Dota, the capital of the canton of Tarrazú, the next night Santa María de Dota, and the C. del Angelo, small valley of El Copey 1790 m., and El Roble 2670 m., on the following day. On January 18 they passed Alto de la Baraja 2933 m., Rancho de las Vueltas, C. de las Vueltas 3019 m., and Ojo de Agua 2760 m.; on January 19 the Paramo de las Vueltas and the C. de Buena Vista 3299 m., and La Muerte at 3130 m.; on the 20th, southward along the slopes of Buena Vista to Lagunilla 1857 m., the Alto del Palmital at 1211 m., reaching El Général on the evening of January 21 where they stayed until January 28, 1891, and whence Biolley returned to San José. Pittier and Tonduz continued to Buenos Aires, Térraba, and Boruca, whence Pittier returned by a somewhat different route to San Marcos and San José, arriving on February 23, while Tonduz stayed in the field until March 8, 1891.

The following season Tonduz left San José on October 18, 1892, more or less retracing the journey of the previous season to Buenos Aires, thence down the R. Grande de Térraba or Diquís, stopping some time at Boruca, finally down the river to the coast and back by sea to Puntarenas, stopping at several points, arriving on April 17, 1893. The material from these two trips furnished the bulk of material upon which Müller Argau (1891, 1893) based his account of the lichens.

These collections are to be found in the Herbarium Müller Argau,

which was purchased by the *Herbier Boissier* and is now at the *Université de Genève*. I have been told that a duplicate set exists in Brussels, but apparently none was returned to the *Museo Nacional* in San José.

C. Wercklé, an engineer who resided in Costa Rica for many years, collected much in the vicinity of Cartago. His specimens were determined by Lindau and may be seen in Berlin and in Wercklé's herbarium at the *Museo Nacional de Costa Rica*. Wercklé was not at all discriminating in selecting samples for Lindau, so that most of the material in San José needed revision.

The Calverts (1917) spent a year, 1909–1910, in Costa Rica and have given us a good account of its natural history. They brought back some plants which are in the herbarium of the University of Pennsylvania, but I have seen only one lichen from them (at the Farlow Herbarium). Maxon and assistants have visited Costa Rica for ferns and brought back some lichens which were sent to G. K. Merrill for study and are now to be found in the Farlow Herbarium (which acquired the Merrill herbarium) and in the National Herbarium of the Smithsonian Institution at Washington.

Paul C. Standley, in 1924 and again in 1925–6, in company with Juvenal Valerio Rodriguez and Ruben Torres Rojas, made very extensive collections of lichens although his primary interest was angiosperms. These lichens were likewise sent to G. K. Merrill who was studying them at the time of his death. As curator of the Farlow Herbarium I continued this study in preparation for my trip to Costa Rica and am here reporting these collections.

In 1925, during a two-weeks' visit, I secured a large amount of material from Cerro Carpintera and again in 1929–30 I secured several thousand specimens of cryptogams which are still being studied. The most complete set of these plants is in my personal herbarium and the next set, lacking only a few numbers of the commoner species, is at the Farlow Herbarium.

Karl Danielson, an assistant to H. E. Stork, in 1928 collected a few numbers of lichens which are now at the University of Michigan. These are also reported here for the first time, duplicates being found in the Farlow Herbarium and in my own herbarium.

In 1929 and 1930 the Costa Rican government botanist, Alberto M. Brenes, collected many lichens in the vicinity of San Ramón and a few from other parts of the country. These were also turned over to me for study and are to be found in the Museo Nacional, with duplicates in my own herbarium and in the Farlow Herbarium.

The Oesterreichische Costa Rica Expedition, under the leadership of Otto Porsch (1932) with G. Cufodontis as assistant botanist, spent the late verano and early invierno in Costa Rica, visiting much the same territory as I did. If lichens were collected they were probably studied by Zahlbruckner but I have seen no publication on this group, although many of the other groups are already published.

FLORISTICS

It is too early to draw any very definite conclusions regarding the distribution of plants and the affinities of the flora, but certain typical distributions are evident.

Families and genera which are abundant in the northern United States and are often widespread in the North Temperate Zone are usually found at the higher altitudes and reach their southern limits in the mountains of Colombia, except for occasional isolated species farther south. Such an example is the Peltigeraceae, which are widespread and abundant in the northern part of the United States. Only two genera, *Nephroma* and *Peltigera*, reach the American tropics. *Nephroma* is represented by a single species seen in only one restricted locality in Costa Rica. *Peltigera* is represented by about eight species, mostly strictly tropical with only one undescribed species reaching Magellanes, Chile.

Another typical example is a northern family, which is characteristic of the Atlantic Coastal Plain, the Collemaceae. Here genera are mostly common to the eastern and western hemispheres but subgenera and species are much more restricted in distribution. These are mostly found on the coastal plains of Costa Rica, being characteristic on the plains of Guanacaste and occasional on the Atlantic Coastal Plain but not yet reported from Panamá. The species belonging in these genera from the

higher elevations have relations with those of the mountains of Colombia and not with those north of the Isthmus of Nicaragua.

A third type of distribution is found in those families which are predominantly southern, as in the Stictaceae. Here we find them highly developed and characteristic in the highlands, relatively rare in the lowlands. The genera and subgenera are world-wide in distribution and the species also have wide ranges, becoming less frequent in numbers and in species in the North Temperate Zone. In this group, however, species of the mountains of Costa Rica may extend into North America along the Atlantic Coastal Plain, even as far as the Avalon peninsula of Newfoundland, while the species of the Coastal Plain in Costa Rica are southern in their ranges.

Finally some cosmopolitan families in which it is difficult to determine a center of distribution have genera or subgenera which are strictly limited to tropical America.

Further consideration of problems of distribution may be deferred until the systematic enumeration is complete. In general the affinities of the flora seem to be with eastern Brasil but since we have very few collections available from the intermediate mountain ranges of eastern Colombia and southern Venezuela and British Guiana, it is likely that stations of many of these species will eventually be discovered in these regions. Relatively few species are common to Mexico and Costa Rica or to Perú and Costa Rica, and practically no Costa Rican species extend as far south as Chile.

In the following systematic enumeration I have included in the keys to species all those which have been described from tropical America, whether they have been found in Costa Rica or not. I have not included species which were not originally described from this area, although they may have been reported from it, since often these reports have been based on misdetermined specimens. While it is evident that political boundaries do not always coincide with natural floristic divisions, for the purposes of this study tropical America may be defined as Mexico and the West Indies southward to Perú, Bolivia, Paraguay, Brasil, and Uruguay. These are quite natural in the present state of our knowledge, as the lichen flora of northern

Mexico which might be expected to show affinities with that of the southwestern United States is practically unknown. Similarly, that of northern Argentina, which might be expected to be similar to that of adjacent Paraguay, has been little explored for cryptogams. Northern Chile, largely desert, has also been little studied, while the flora south of the desert has relatively few species which have been reported from tropical America as here defined. The greatest difficulty occurs in the exclusion of southern Florida where occur many species which are tropical rather than northern in their affinities. Fortunately for our purposes comparatively few species have been described from this region.

KEY TO TROPICAL AMERICAN FAMILIES
OF

FOLIOSE AND FRUTICOSE LICHENS

- Apothecia more or less exposed, paraphyses growing above the asci to form a tissue, asci early evanescent, leaving an enclosed dusty spore mass (mazedium) CONIOCARPINEAE
- Thallus foliose or fruticose, corticate, apothecia sessile SPHAEROPHORACEAE
- Apothecia linear, elongate-elliptic or angular, not forming a mazedium GRAPHIDINEAE
- Thallus fruticose, erect or dependent, with a basal layer attached to the substrate, corticate [not yet reported between Lower California and Perú]; maritime ROCCELLACEAE
- Apothecia circular, not forming a mazedium CYCLOCARPINEAE
- Thallus strictly crustose, but fruiting structures appearing fruticose owing to the proliferation of the apothecia from the margins, easily mistaken for a hepatic on cursory examination; Guiana *Polystroma*
- Thallus loosely byssine from filaments of *Cladophora* or *Trentepohlia*, apothecia with light-colored parathecium COENOGONIACEAE
- Thallus filiform or dwarf fruticose, or squamose, very rarely small foliose [deferred for further treatment with the crustose species].
- Algal symbiont *Scytonema* or *Stigonema*, apothecia more or less sunk in the thallus, small and easily overlooked EPHEBACEAE
- Algal symbiont Chroococcaceae PYRENOPSISACEAE
- Algal symbiont *Rivularia* LICHINACEAE
- Thallus gelatinous, swelling greatly when moistened, dwarf fruticose, squamose or large foliose, algal symbiont usually *Nostoc* COLLEMAACEAE
- Thallus definitely foliose or fruticose, or if small, the form of the thallus not due to the algal symbiont.
- Hypothallus and rhizoids highly developed, thallus squamose to small foliose, upper surface corticate, algal symbiont usually *Nostoc* PANNARIACEAE
- Hypothallus evanescent.
- Thallus large foliose, algal symbionts Nostocaceae or Palmellaceae, spores fusiform to acicular, 2 or more celled.

- Both surfaces corticate, lower surface interrupted by more or less highly developed breathing pores, apothecia with well-developed parathecia or amphithecia, stipitate or sessile. . . . STICTACEAE
- Only upper cortex developed, the lower surface tomentose with more or less highly developed network of veins and tufted rhizoids, apothecia attached to the thallus over their whole under surface without true parathecium or amphithecium although surrounded by the torn remains of the tissue covering the young apothecium. . . . PELTIGERACEAE
- Thallus squamose or small foliose, only upper surface corticate, algal symbiont *Pleurococcus*, apothecia with well-developed light-colored parathecium, spores various.
- No secondary thallus or podetia present, apothecia sessile. . . . PHYLLOPSORACEAE
- Secondary thallus or podetia present, varying from simple stalk of apothecium without algae to highly developed branched or infundibuliform structures, primary thallus squamose or small foliose, often evanescent or degenerate, perhaps crustose in some species. . . . CLADONIACEAE
- Thallus large foliose or fruticose, algal symbiont *Pleurococcus*, spores one- or two-celled or muriform, never elongate-fusiform to acicular.
- Apothecia with black parathecium, spores one-celled [in *Gyrophora haplocarpa* from Perú, the only species of the family so far reported]. . . . GYROPHORACEAE
- Apothecia with bright-colored amphithecia.
- Spores not placodimorphous.
- Thallus foliose, spores one-celled. . . . PARMELIACEAE
- Thallus fruticose. . . . USNEACEAE
- Spores placodimorphous.
- Spores hyaline, thallus usually bright yellow, at least the epithecium orange. . . . THELOSCHISTACEAE
- Spores brown, thallus usually more or less glaucous, epithecium brown or pruinose. . . . PHYSCIACEAE

SPHAEROPHORACEAE

Thallus foliose or fruticose, corticate on both surfaces or the lower surface incompletely corticate, with *Protococcus*. Apothecia sessile on the margin, or on the lower side of the thallus, open at first or enclosed by an amphithecium.

Only two genera have been reported from tropical America, both fruticose with solid axis and terminal apothecium. *Acroscyphus sphaerophoroïdes* Lév. without an amphithecium has been reported from Mexico and Perú but has not been found in Costa Rica. *Sphaerophorus* is typically Subarctic-Antarctic in distribution, coming southward on the higher mountains with

a single species on the higher mountains of tropical America. The whole family is greatly in need of revision.

SPHAEROPHORUS MELANOCARPUS (Sw.) DC. apud Lam. & DC., Fl. Franç. ed. 2, 6: 178. 1805, excl. syn.

Lichen melanocarpus Swartz, Nova Gen. Sp. Pl. Prodr. 147. 1788.

Type: Jamaica, *Swartz*.

Thallus ashy glaucescent or pale above, pale below, partly terete, partly compressed, smooth, not rugose, highly branched, 1–6 cm. high, primary branches 1–4 mm. thick, KOH yellow above, KOH – below, CaOCl_2 – ; cortex 20 μ thick, subpellucid, of thick-walled conglutinate irregularly woven hyphae; medulla I –, composed of hyphae 4–8 μ thick; mazedium oblique in the ends of the thicker terete branches, becoming disciform, exciple lacerate, ascospores 7–11 μ in diameter. Spermatogonia immersed in the tips or in the lower surface of the branches, opening by a blackened verruciform mouth; spermatia oblong, 1 x 3 μ [description from Nylander and Vainio].

The Costa Rican material does not altogether agree with the above description, but there is so much variation in macroscopic appearance that only a careful monograph can settle the number of species and their relationships.

Cartago: F. V. Turrialba, 2000–2400 m., *Standley 35313*.

San José: L. la Chonta, n. e. Sta. María de Dota, 2000–2100 m., *Standley 42290*;
C. de las Vueltas, 2700–3000 m., *Standley & J. Valerio 43832*.

Heredia: C. Zurquí, 2000–2400 m., *Standley & J. Valerio 50436*.

ROCELLACEAE

This strictly maritime family has not yet been reported between Lower California and Perú, probably because no suitable maritime habitats have been visited by botanists, for the group is abundant in such strictly tropical habitats as the Galápagos Islands. I did not have an opportunity to visit such myself, but had I been able to visit the cliffs along the various headlands between Puntarenas and Golfo Dulce, it is possible that I might have secured some representatives of this family.

COENOGONIACEAE

Thallus spongy byssoid, either adnate or forming dimidiate shelving masses, homoeomerous with *Trentepohlia* or *Cladophora*,

whose filaments are partially surrounded by hyphae. Apothecia with pseudoparenchymatous parathecium; asci 8-spored; spores hyaline, one- or two-celled; spermatia exobasidial.

Thallus with *Trentepohlia* *Coenogonium*
Thallus with *Cladophora*, apothecia unknown *Racodium*

COENOGONIUM Ehrenb.

COENOGONIUM Ehrenberg apud Nees ab Esenbeck, Horae Physicae Berol. 120. 1820.

Thallus loosely spongy byssoid, either adnate or forming dimidiate shelving masses (suggesting a thin species of *Polystictus*), homoeomerous with *Trentepohlia* which is partially surrounded by a network of hyphae. Apothecia scattered on the upper surface, scutiform, usually with a short stipe, with a parathecium of thin-walled pseudoparenchyma without a medulla; paraphyses unbranched, often with swollen tips; asci 8-spored; spores hyaline, fusiform, ellipsoidal to elongate, one- or two-celled; spermatia spherical, spermatia exobasidial, fusiform, straight; spermatophores mixed with anaphyses.

Clements segregated the species of *Coenogonium* with unicellular spores as *Holocoenis*. However, his proposal has not been followed by other authors, although Vainio and Zahlbruckner have proposed sections on this basis, Vainio using *Coenobiatora* and *Coenobiatorina*, while Zahlbruckner incorrectly adopted *Holocoenis* and *Coenobiatorina*.

This family is very aberrant among lichens in several respects and perhaps would be better dropped and the species distributed among the fungi and algae. It seems more logical to regard the group as a case of parasitism of fungi on algae, as neither fungus nor alga seems to influence the development of the other, and there has been no further evolution resulting from the acquisition of a photosynthetic unit by the fungus. Taking this view, one would recognize about four or perhaps five species of fungi from tropical America, one species with unicellular spores about 6-10 x 2.5-4 μ belonging in *Patinella*; and three or four species with 2-celled spores belonging in *Orbilina* or a segregate from that genus. Among the algae one would recognize a dozen or more species of *Trentepohlia* which are often subject to the attacks

of *Patinella* and *Orbilina*. In the following key to the tropical American species of *Coenogonium*, as it is commonly understood by lichenologists, it will be noted that out of nineteen names proposed, four were based on specimens in which no apothecia were found. Four other species originally described in *Coenogonium* have already been transferred to *Trentepohlia*. I have carefully investigated the ascocarps of the fertile Costa Rican specimens and can find few characters which would separate species from each other, except spore size and septation. For lack of time to investigate this question thoroughly, I have here followed the traditional arrangement, as to do otherwise would involve serious nomenclatorial difficulties. To adopt the view that this group should be excluded from the lichens would invalidate *Coenogonium*, as based on a combination of characters of parasite and host and involve redescription of its species in *Patinella*, *Orbilina*, and *Trentepohlia*.

KEY TO THE TROPICAL AMERICAN SPECIES OF COENOGONIUM

- Apothecial disc livid, cell walls brownish; spores unicellular; algae 11–16 μ in diameter; French Guiana. *C. Leprieurii*
- Apothecia carneous, yellowish or waxy white, never livid.
- Thallus dimidiate, not adnate to the substrate.
- Thallus thick, rigid, with white subsilky villum, zonate, sterile; Brasil. *C. Echinus*
- Thallus thinner.
- Filaments 7–9 μ in diam., cells not very distinct, greenish, subdiffuse, stratose. *C. subvirescens*
- Filaments 12 μ in diam., rigid; Brasil. *C. Linkii*
- Filaments thicker, 16–20 μ in diam., thallus less rigid.
- Cells 4–5 times as long as broad; Mexico. *C. confervoides*
- Cells about twice as long as broad; spores 7–8.5 x 2–3 μ ; Brasil. *C. acrocephalum*
- Filaments and paraphyses thick, imperfectly known. *C. andinum*
- Thallus adnate to effused.
- Filaments moniliform, 18 μ in diam.; thallus glaucous green to tawny brown, margins paler; spores 2-celled, 3–4 times as long as broad; Cuba. *C. moniliforme*
- Filaments partially moniliform, partly cylindrical, cells 20–25 μ in diam.; Costa Rica. *C. heterotrichum*
- Filaments uniformly cylindrical.
- Filaments 23–36 μ in diam.; striate apothecia 0.6–0.7 mm. in diam.; spores 11–15 x 25–35 μ , 2-celled. *C. disjunctum*
- Filaments 20–28 μ in diam.; spores unicellular, 6–10 x 3 μ ; Bononia or Louisiana. *C. interpositum*

- Filaments 17–20 μ in diam.; cells 30–50 μ long; spores 8 x 2.5 μ , 2-celled; Costa Rica.....*C. interponendum*
- Filaments 15–17 μ in diam.; thallus ashy green, pulvinate, up to 2 cm. broad; Perú.....*C. pulvinatum*
- Filaments 12–16 μ in diam.; thallus yellowish; spores 8–10 x 3 μ ; Colombia.....*C. interplexum*
- Filaments 12–14 μ in diam.; thallus yellowish to green; St. Vincent.....*C. Leprieurii* v. *panniforme*
- Filaments 8–11 μ in diam., conglutinate in fascicles 70–90 μ in diam.; spores 7–10 x 3.5–4.5 μ ; Bolivia.....*C. complexum*
- Filaments 4–8 μ in diam.
 Filaments non-articulate; spermatia 7–9 x 15 μ ; paraphyses clavate; Brasil.....*C. dialeptizum*
- Filaments articulate; spermatia not reported.
 Cells 2.5–4 times as long as broad, paraphyses obovoid; Brasil.....*C. pannosum*
- Cells 1.5–3 times as long as broad, sterile; Brasil.....*C. depressum*
- Filament size not given, rugulose, articulate-branched, coalesced into fascicles; Venezuela.....*C. Tuckermanni*

COENOGONIUM LEPRIEURII Nyl., Ann. Sci. Nat. Bot. IV, 16: 89. 1862.

C. Linkii var. *Leprieurii* Mont., Ann. Sci. Nat. Bot. III, 16: 47. 1851.

Holocoenis Leprieurii Clements, Genera of fungi, 174. 1909.

Type: Guayane Française, *Leprieur*, sine no.

Algae loosely woven, yellowish, 11–16 μ in diameter. Apothecia plane or convex, excluding the white margin, disc livid from the first; asci about 20 μ in diameter; spores oblong to fusiform or ellipsoidal, unicellular, 6–10 x 2.5–4 μ ; paraphyses slender, apices clavate.

I have not seen this species from Costa Rica but *Dodge & Nevermann* 7399, from jungle at Castilla farm, 20 m., Limón Province, seems to be a variety of this species. The fungus is not well developed but has a livid disc, the margin is still thick and white, and the alga is of much smaller diameter. The exciple is composed of isodiametric cells with colored walls. It appears to be the same fungus attacking a much smaller alga, and should be referred to *Patinella*.

COENOGONIUM SUBVIRESCENS Nyl., Flora 57: 72. 1874.

C. Leprieurii var. *subvirescens* Nyl., Ann. Sci. Nat. Bot. IV, 16: 89. 1862.

Type: Brasil, Amazonas, Rio Negro, *Spruce* 28, is type of the

species, while *C. Leprieurii* var. *subvirescens* was described from French Guiana without collector.

Algae somewhat interwoven but more or less parallel, 7–9 μ , forming a loose dimidiate to subcircular thallus depending upon position and shape of substrate, not or obscurely zonate, pale to dark olive buff, cells about 21–24 μ long, septa not very evident, other cell walls thick, chloroplasts appearing somewhat in the shape of a dumb-bell with the pigment more or less massed at the ends of the cells.

Apothecia about 800 μ in diameter, tapering below to a short stipe about 250 μ in diameter, composed of thick-walled pseudo-parenchyma with the outer 40 μ composed of a palisade of elongate cells, perpendicular to the surface; parathecium about 80 μ thick, homogeneous with the rest of the apothecium, the hypothecium very thin, filamentous, of cells with thinner walls. The hymenium is about 80 μ tall and is composed of filiform paraphyses with clavate tips and slender clavate asci. The ascospores are not mature in my specimens but seem to be slender, 2-celled, probably about the size of most of the other spores in the genus except *C. disjunctum*.

Limón: Cadiz, *Dodge* 7452; Castilla farm, 20 m., *Dodge & Nevermann* 7451; Monte Verde, *K. Danielson* 73; Siquirres, 70–200 m., *Dodge, Catt & Thomas* 5574; La Colombiana, 70–80 m., *Standley* 36885.

Cartago: R. Pejivalle, 650–800 m., *Dodge & Thomas* 4408; El Muñeco, on R. Navarro, 1400–1500 m., *Standley & J. Valerio* 51055; C. Carpintera, 1500–1850 m., *Standley* 35596.

Puntarenas: Osa, Golfo Dulce, *Dodge* 7450.

Guanacaste: Q. Serena near Tilarán, 700 m., *Standley & J. Valerio* 46242; Santa-maria, 720–850 m., *Dodge* 7015.

COENOGONIUM LINKII Ehrenberg ap. Nees ab Esenbeck, *Horae Phys. Berol.* 120. 1820.

C. controversum Pers. ap. Gaudich. in Freycinet, *Voy. Uranie*, Bot. 214. 1826 (nom. nud.).

Type: Brasil, Sta. Catharina, *Chamisso*. The type of *C. controversum* came from the walls of the aqueduct of Corcovado, Rio de Janeiro, *Gaudichaud*.

Algae somewhat interwoven but more or less parallel, about 12 μ in diameter, forming a somewhat rigid dimidiate to sub-orbicular thallus, not or obscurely zonate, pale to dark olive-buff, cells 40–60 μ long, septa very difficult to observe, chloro-

plasts small and scattered, outer cell walls thick, partially covered with anastomosing fungal hyphae.

Apothecia warm buff, about 850 μ in diameter, tapering sharply to a short stipe about 240 μ in diameter and up to 300 μ long, pseudoparenchymatous, without palisade layer at the surface; parathecium about 100 μ thick, homogeneous with the rest of the apothecium, the hypothecium very thin and soon evanescent; the hymenium about 80 μ tall, composed of filiform paraphyses with swollen tips and cylindrical asci. The ascospores are not fully mature in my specimens but probably the common size for the genus.

Cartago: C. Carpintera, 1800 m., *K. Danielson* 9.

Alajuela: La Palma de S. Ramón, 1100 m., *Brenes* 175.

Guanacaste: El Silencio, near Tilarán, 750 m., *Standley & J. Valerio* 44619.

COENOGONIUM CONFEROIDES Nyl., *Flora* 41: 380. 1858.

? *C. andinum* Karsten ap. Nyl., *Bot. Zeit.* 20: 178. 1862.

Type: Mexico, Orizaba, *Fr. Müller* (*Schimper* Herb.). Type of *C. andinum* from Colombia, 2000 m., *Lindig* 2560, also Perú, *Weddell*, and southern Brasil, *Guillemin*. Since I have been unable to see the types, the interpretation of this species is difficult. In *Ann. Sci. Nat. Bot.* IV, 11: 242. 1859, Nylander amplified his very inadequate description, basing his emendations on a specimen from Tahiti, *Lépine* 14. When he monographed the genus in *Ann. Sci. Nat. Bot.* IV, 16: 91. 1862, he cited *Lépine* 14 from Tahiti first, adding Guadeloupe Island, *Duchassaing*, Brasil, *Gaudichaud*, and *Weddell*, and Chile, *Gay*, not citing the original Mexican type. Since none of these descriptions was based on specimens having apothecia its application is further confused. Since the descriptions only state how it differs from *C. Linkii*, I have assumed that the thallus is more or less dimidiate with a larger alga than in that species. Nylander also notes that a specimen from Colombia, Bogota, 2700 m., *Lindig* 887, has algal filaments 12–18 μ in diam. Unfortunately I have been unable to see any of the above-mentioned specimens. The following description is based on Costa Rican specimens.

Algae somewhat interwoven but more or less parallel, 16–20 (–28) μ in diameter, forming a soft dimidiate or suborbicular thallus, not zonate, pale to deep olive buff, cells about 60–100 μ

long, septa plainly visible, chloroplasts rather indistinct in these specimens, often alternate cells more or less collapsing, giving a somewhat moniliform appearance to old filaments, outer walls thick, not densely covered with hyphae. The collapsed cells sometimes have the coloring matter collected at the ends, giving the dumb-bell appearance to the chloroplast as in *C. subvirescens*.

Apothecia warm buff, 560 μ in diameter, patelliform, with stipe about 160 μ in diameter and 300 μ long, pseudoparenchymatous, of very thick-walled cells which tend to arrange their long diameters perpendicular to the surface of the apothecium, but not forming a definite palisade as in *C. subvirescens*; the parathecium 40–50 μ thick, homogeneous with the rest of the apothecium, the hypothecium 20–30 μ thick of interwoven hyphae, the hymenium about 60 μ tall, composed of filiform paraphyses with spherical tips and slender cylindrical asci about 5 μ in diameter; ascospores distichous, 4-celled, 10–12 x 3 μ . [The ascospores are immature and so closely packed in the ascus that I am not certain of size and septation, as I have been unable to free spores from the ascus.]

Limón: Waldeck, *Dodge 7453*.

Cartago?: Morpho Valley, 1420 m., *K. Danielson 51* [This locality is uncertain and Danielson's barometric readings are apt to be a little high, but it probably in the vicinity of the upper Reventazón below Cartago, where Lepidoptera of the genus *Morpho* are not uncommon.]

COENOGONIUM HETEROTRICHUM Müll. Arg., Bull. Soc. R. Bot. Belg. 32: 162. 1893.

Type: Costa Rica, San Marcos de Dota, *Tonduz 6115*.

Thallus pulvinate, cespitose-effused, deep olive buff to dark olive, algae somewhat interwoven, dimorphic, larger filaments 20–25 μ in diameter, cells about 40 μ long, chloroplasts disciform, scattered; smaller filaments submoniliform, the cells of smaller diameter being about 7–8 μ and 12 μ long, those of larger diameter being about 10–12 μ and of about the same length.

Fungus unknown. In *Brenes 29a* the fungal hyphae are brown instead of hyaline.

San José: S. Marcos de Dota, 1200 m., *Tonduz 6115*, type.

Alajuela: La Palma de S. Ramón, 1250 m., *Brenes 29a*.

COENOGONIUM INTERPONENDUM Nyl. ap. Polakowsky, Jour. Bot. Brit. & For. 15: 225. 1877.

Type: Costa Rica, Cartago, Angostura, *H. Polakowsky* 496.

Algae loosely interwoven, forming an adnate irregular thallus, deep olive buff to citrine drab, cells about 17–20 μ in diameter, 30–50 μ long, pigment quite uniformly dispersed throughout the cell, yellowish green. All my Costa Rican material is sterile. Nylander states that the spores are fusiform, 2-celled, 8 x 2.5 μ .

Limón: Carmen, *Dodge* 7449.

Cartago: Angostura, *H. Polakowsky* 496, TYPE.

Alajuela: La Palma de S. Ramón, 1250 m., *Brenes*, 53a, 116, 399.

Guanacaste: H. Q. Azul on lower slopes of V. Tenorio, 400–600 m., *Dodge & Thomas* 8042.

COENOGONIUM INTERPOSITUM Nyl., Ann. Sci. Nat. Bot. IV, 16: 91. 1862.

Type: Borbonia, Lepervanche, *Mezières*; Louisiana, *Hale*.

Thallus loosely tomentose intertangled, more or less pulvinate, algal cells 20–28 μ in diameter and 60–88 μ long, chloroplasts appearing the shape of a dumb-bell with the pigment massing at the ends of the cells.

[Apothecia pale carneo-luteous; spores oblong, simple, 6–10 x 3 μ ; paraphyses slender or medium.]

As all my Costa Rican material is sterile the reference of it to this species is doubtful. It quite possibly belongs with *C. disjunctum* Nyl., based on specimens from Martinique and Cuba, *Wright* 170, which reaches a slightly larger diameter of algal filament and much larger 2-celled spores. Both species are said to resemble *C. confervoides* and perhaps should be placed in the *C. confervoides* group.

Cartago: C. Carpintera, 1560–1700 m., *Dodge & Thomas* 7920.

Alajuela: La Palma de S. Ramón, 1100–1250 m., *Brenes* 53, 115.

COENOGONIUM INTERPLEXUM Nyl., Ann. Sci. Nat. Bot. IV, 16: 92, pl. 12, f. 20, 21. 1862.

Type: Colombia, 2200 m., *Lindig* 2561.

Thallus loosely interwoven, intricate, algal cells 12–16 μ in diameter and 30 μ long, chloroplasts more or less disciform, scattered.

[Apothecia fleshy-yellow, plane, 1 mm. in diameter, margin waxy, fleshy to white; spores short-fusiform, 2-celled, 8–10 x 3 μ ; paraphyses medium, apex clavate.]

Alajuela: Piedades de S. Ramón, 900 m., *Brenes* 408.

Puntarenas: Boruca, 560 m., *Tonduz* 6114.

COENOGONIUM PANNOSUM Müll. Arg., Flora **64**: 234. 1881.

Type: Brasil, São Paulo, Apiahy, *Puiggari* 1026.

Thallus loosely interwoven, dark olive buff to citrine drab, more or less adnate to substratum, algal cells 6–8 μ in diameter, 28–32 μ long, pigment migrating toward the ends of the cells.

[Apothecia 350–500 μ in diameter, pale or orange white, plane, with paler and thinner margin, finally immarginate and slightly convex, becoming more flesh color; hymenium hyaline, paraphyses very slender with obovoid head about three times as thick as the stalk; asci slender, cylindrical, 8-spored; spores 2-locular, 6–7 x 2 μ , fusiform with acute ends.]

Since my Costa Rican material is sterile its reference here is uncertain and it may be only very young algae of *C. subvirescens* Nyl., with which it agrees in general appearance, but there is no trace of the formation of a dimidiate thallus.

Guanacaste: H. Q. Azul, on slope of V. Tenorio, 500–600 m., *Dodge & Thomas* 6654.

COENOGONIUM DEPRESSUM Müll. Arg., Flora **64**: 525. 1881.

Type: Brasil, São Paulo, Apiahy, *Puiggari* 1034.

Thallus adnate, pale olive buff, filaments short, flexuous, depressed, subintricate; cells 4–8(–13) μ in diameter, 16–20 μ long, somewhat inflated in the middle but scarcely enough to give a moniliform appearance, chloroplasts no longer distinct.

As I have not compared the Costa Rican material with the type I cannot be certain of the identity.

Cartago: alpine region of Irazú, *Ørsted*.

COENOGONIUM IMPLEXUM Nyl., Ann. Sci. Nat. Bot. IV, **16**: 92. 1862.

Type: Australia, Victoria, Jarvin, *Ferd. Müller*.

[Similar to *C. interplexum* but algal cells a little smaller, 10–13 μ in diameter, spores a little larger, 8–11 x 3.5–4.5 μ , paraphyses thicker.]

The following collection has been referred here by Müller Argau, but I have not studied it.

Puntarenas: Boruca, 560 m., *Tonduz* 6113.

EPHEBACEAE

Thallus dwarf fruticose, branched, more or less filiform, without rhizinae, crustose or small squamose, with *Scytonema*

or *Stigonema*. Apothecia small, often with very small punctiform disc, scarcely visible; paraphyses well developed or absent; asci 8-spored; spores hyaline, 1-2-celled.

The individuals of this family are so small that they are easily overlooked both in collecting and in sorting material, and so the few species here reported are probably not representative of this group in Costa Rica.

KEY TO TROPICAL AMERICAN GENERA OF EPHEBACEAE

Thallus crustose to small squamose, homoeomeric; Brasil.....*Pterigypsyis atra*
Thallus dwarf fruticose, dark, thickly branched.

Apothecia sunken in swellings of the thallus, single or gregarious; spores unicellular; paraphyses present; Brasil.....*Ephebeia*

Apothecia sessile on the thallus, either lateral or terminal.

Thallus without pseudoparenchymatous cortex or medulla; paraphyses filiform, simple; asci 8-spored; spores ovoid or spherical, unicellular.....*Thermutis*

Thallus with pseudoparenchymatous cortex and medulla.

Spores unicellular.....*Leptogidium byssoides*

Spores 2-celled.....*Polychidium*

THERMUTIS E. Fr.

THERMUTIS E. Fr., Syst. Orb. Veg. 1: 392. 1825.

Gonionema Nyl., Mem. Soc. Sci. Nat. Cherbourg 3: 163. 1855.

Thallus dwarf fruticose, thickly branched and filiform, without rhizinae, *Scytonema* present with the hyphae running in the gelified sheath. Apothecia small, lateral, saucer-shaped to almost spherical; parathecium often highly developed and thick; hypothecium light-colored; paraphyses unbranched, filiform, tips not swollen; asci clavate, thin-walled, 8-spored; spores hyaline, ellipsoidal, elongate, unicellular, thin-walled. Spermatogonia lateral or terminal, sessile, more or less spherical; spermatia small, ovoid, or elongate.

THERMUTIS VELUTINA (Ach.) Fw., Linnaea 23: 170. 1850.

Lichen velutinus Ach., Lichenog. Suec. Prodr. 218. 1798.

Gonionema velutina Nyl., Act. Soc. Linn. Bordeaux 21: 262. 1856.

This species has been reported by Müller Argau from the following localities in Costa Rica. The specimens were not studied while I was in Genève.

San José: San Marcos de Dota, 1200 m., *Tonduz* 5378.

Guanacaste: Boruca, 560 m., *Tonduz* 5371; Térraba, *Tonduz* 5372.

A small sterile specimen from Guanacaste: near Tilarán, 500–690 m., *Dodge & Thomas 8031*, may belong in *Polychidium* but the specimen is not definitely determinable as to genus.

COLLEMACEAE

Thallus gelified, crustose to foliose or dwarf fruticose, with or without rhizoids, sometimes umbilicate, homoeomerous with *Nostoc*. Apothecia from sunken almost perithecia to sessile apothecia usually with an amphithecium, occasionally with parathecium; paraphyses simple; asci 8-spored; spores hyaline, spherical to acicular, straight or twisted, 1-celled to muriform, usually with a thin wall (except in *Physma* and section *Lemphospora* of *Lempholemma*).

This family is widely distributed in the temperate and tropical zones, the more highly developed members occurring in the latter. It is possible that some of the smaller and less conspicuous genera have been overlooked or have been included in the crustose material in the preliminary sorting. So far only four genera have been found in Costa Rica.

KEY TO TROPICAL AMERICAN GENERA OF COLLEMACEAE

Spores unicellular.

Thallus crustose, not gelified, parathecium present; spores ellipsoidal, thin-walled.

Brasil..... *Leprocollema americanum*

Porto Rico..... *L. Finkii*

Thallus squamulose, gelified; spores spherical, thin-walled but surrounded by a thick gelified sheath.

Thallus not corticate..... *Lempholemma*

Thallus corticate, wholly pseudoparenchymatous; Juan Fernandez....

..... *Lemmopsis polyschidioides*

Thallus foliose, gelified; spores ellipsoidal to fusiform, thick-walled, surrounded by a gelified sheath..... *Physma*

Spores phragmospores or dictyospores.

Cortex not developed; apothecia with parathecia only..... *Collema*

Cortex of pseudoparenchyma; apothecia with amphithecia (parathecia

often also present)..... *Leptogium*

LEMPHOLEMMA Körb.

LEMPHOLEMMA Körber, Syst. Lich. Germ. 400. 1855.

Type species: *Lempholemma compactum* Körber.

Thallus from verrucose, squamulose, dwarf fruticose to foliose in our species, gelified when moist, clothed with rhizinae below,

homoeomeric, without cortex, with *Nostoc*. Apothecia superficial or terminal, mostly sunken in the thallus (not in our species); amphithecium either with or without cortex; parathecium colorless, urceolate; hypothecium colorless; paraphyses filiform, simple; asci 8-spored, clavate, often twisted below; spores hyaline, fusiform, ellipsoidal-ovoid or spherical, smooth.

The genus has been divided into eight sections of which only one section *Lemphospora* is tropical. This section is characterized as having apothecia without cortex, spores more or less spherical with a thick gelified sheath. *Lempholemma Dussii* (Vainio) Zahlbr., Cat. Lich. Univ. 3: 23. 1925 [*Collema Dussii* Vainio, Ann. Acad. Sci. Fenn. A67: 114. 1915] has been described from Guadeloupe in the Antilles.

LEMPHOLEMMA (LEMPHOSPORA) **oblique-peltatum** (Eschw. ap. Martius) Dodge, comb. nov.

Collema oblique-peltatum Eschw. ap. Martius, Icon. Pl. Cryptog. Fasc. 2: 27, pl. 11, f. 2 [between 1828 and 1833].¹

Type: Brasil, near Pará, *Martius*.

Thallus foliose, up to 5 cm. in diameter, drying grayish olive to dark olive gray, margin thick, broadly subdichotomously lobed, lobes up to 3 mm. broad and 2-3 mm. long, smooth, surface minutely pitted although appearing practically smooth to the naked eye, without soredia or isidia; thallus 200-400 μ thick, homoeomeric, without cortex, but provided with a thin layer of tangled rhizinae below. Apothecia subsessile, often appearing obliquely attached to the thallus in section, up to 2.5 mm. in diameter, margin of the same color as the thallus, with periclinal folds and wrinkles, disc tawny to mars brown; amphithecium appearing lobulate in section (due to the periclinal wrinkles), homogeneous with the thallus, 200-300 μ thick but extending beyond the parathecium as much as 800 μ ; parathecium pseudoparenchymatous, highly developed, about 100 μ thick below, thinning out above to about 50 μ ; hypothecium about 40 μ thick, of highly gelified hyphae; thecium about 100 μ

¹ I have been unable to locate the date of the second fascicle of this work. The cover of the copy in the Missouri Botanical Garden gives the pages of text and plates in each fascicle but only the dates 1828-1834. Martius in his 'Flora Brasiliensis' 1: 233-234. 1833, quotes from the 'Icones' citing page, hence it must have been issued before that date. In this work he placed it in the subgenus *Enchylium*.

tall; paraphyses about 1–2 μ in diameter, clavate above, septate, cells 4–6 μ long, with walls highly gelified so that they appear as slender rows of cells imbedded in a gel; asci clavate-cylindrical, about 80 x 16 μ , containing 8 monostichous spores; ascospores broadly ellipsoidal, 12 x 8 μ while still in the ascus, with a thick gelified wall.

While I have not studied the type specimen of this species, a careful study of the description and the figures shows that it belongs in *Lempholemma* section *Lemphospora* rather than in *Collema*. Judging from determinations observed in various herbaria, this species seems to have been confused with *Leptogium vesiculosum* (*L. bullatum*), *L. tremelloides*, and *L. foveolatum*, although the abundant development of rhizoids below should have separated it. While it is minutely scrobiculate-foveolate (visible under hand-lens), it is not conspicuously so to the naked eye as in *L. foveolatum*. Besides my Costa Rican material I have also seen it from Eustis, Lake Co., Florida, *Nash 2024*, determined by Eckfeldt as *L. faveolatum* (sic) Nyl.

Limón: Waldeck, *Dodge 7404*; near Siquirres, 70–170 m., *Dodge, Catt & Thomas 5588, 8024*; Hamburg, 55 m., *Standley & J. Valerio 48767*.

Guanacaste: H. Santamaría, 720 m., *Dodge & Thomas 6898*; near Tilarán, 340–670 m., *Dodge & Thomas 6644, 8022*.

Puntarenas: near Corozál, 5–50 m., *Dodge 8023*; Puerto Jiménez, *Brenes 839*.

LEMPHOLEMMA (LEMPHOSPORA) dichotomum Dodge, sp. nov.

Type: Costa Rica, Guanacaste, H. Granadilla, *Dodge & Thomas 6736*.

Thallus foliosus, ad 5 cm. diametro, 400–650 μ crassitudine metiens, griseo-olivaceus, margine crassiuscula, integra, lobatus, dichotomus, lobi 1–1.5 mm. lati, divergentes, superne longitudinaliter rugosus, sine sorediis isidiisque, inferne rhizinis nigris densissimis intertextis obsitus, homoeomerus, nostocaceus, sine strato corticali. Apothecium peltatum, basi constrictum, ad 2.5 mm. diametro metiens, margine concolori, rugosa, disco fulvo castaneove; amphithecium sectione lobatum, homogeneous, 150–300 μ crassitudine inferne, sed ad 500 μ superne et ultra marginem parathecii; parathecium pseudoparenchymaticum, ad 160 μ crassitudine inferne, attenuatum ad 80 μ superne; hypothecium filamentosum, ad 80 μ crassitudine, hyphis gelifactis; thecium ad 120 μ altum; paraphyses filiformes, apicibus

decompositis brunneis, in materia gelata fixi, cellulis cylindricis, 1 μ diametro, 4–6 μ longitudine metientibus; asci 60 x 10 μ , cylindrici; ascosporae octonae, monostichae, late ellipsoideae, 8 x 12 μ (dum in ascis sunt), membrana incrassata, gelifacta.

Thallus foliose, up to 5 cm. in diameter, 400–650 μ thick, grayish olive, margin thick, smooth, dichotomously lobed, lobes 1–1.5 mm. broad, divergent, upper surface longitudinally wrinkled, without isidia or soredia, lower surface covered with a dense black nap of rhizinae, homoeomerous, with *Nostoc*, without cortical layer either above or below. Apothecium constricted at the base, up to 2.5 mm. in diameter, margin concolorous, irregularly wrinkled, disc tawny to chestnut; amphithecium in sections appearing lobed, homogeneous with the thallus, 150–300 μ thick below but extending up to 500 μ above and beyond the margin of the parathecium which is pseudoparenchymatous, about 160 μ thick below, thinning out to 80 μ at the margin; hypothecium filamentous, 80 μ thick, of gelified hyphae; thecium about 120 μ tall, paraphyses filiform, the apices decomposing brown, imbedded in a gel, cells cylindric, about 1 μ in diameter, 4–6 μ long; ascospores 8 per ascus, monostichous, broadly ellipsoidal, about 8 x 12 μ (while still in the asci), with a thick gelified wall. This species has also been seen from Barro Colorado Island, Gatun Lake, Panamá.

Guanacaste: H. Granadilla, 540 m., Dodge & Thomas 6737.

PHYSMA Mass.

PHYSMA Massalongo, Neag. Lich. 6. 1854.

Dichodium Nyl., Bull. Soc. Linn. Normandie II, 2: 43. 1868.

Type: *Physma Boryanum* Massalongo.

Thallus foliose with rhizinae beneath, corticate with several layers of pseudoparenchymatous cells; algae *Nostoc*. Apothecia superficial, lecanorine, with broad disc, thick margin; hypothecium light-colored; paraphyses filiform; asci 8-spored; spores colorless, ellipsoidal or fusiform, unicellular with thick almost warty wall or with a gelified sheath. Spermatogonia sunk in the thallus, showing above by the dark swelling, surrounded by pseudoparenchyma; spermatophores simple or forked, septate, cells short; spermatia short, straight.

Only two species are known from tropical America, *P. chilensis* Hue from Chile and *P. pruinosum* Vainio, from the Antilles. Material reported from America as belonging to *P. byrsinum* (Ach.) Müll. Arg. (*P. byrsea* (Ach.) Tuck.) is probably mis-determined. Apparently the genus is most highly developed and wide-spread in Oceania and adjacent Asia.

PHYSMA PRUINOSUM Vainio, Ann. Acad. Sci. Fenn. A67:112. 1915.

A single sterile specimen collected near Cartago, 1500 m., C. Wercklé, May 1900 (in Mus. Nac. 17233, and in Herb. Bot. Gard. Berlin), was referred to *Physma byrsinum* by Lindau. It is possible that this species belongs to *Physma pruinosum* Vainio or it may possibly be a very young thallus of *Leptogium marginellum* (Sw.) S. F. Gray. Its spermatogonia are marginal and its spermatia are ellipsoidal and small.

COLLEMA Wigg.

COLLEMA Wiggers, Primit. Fl. Holsat. 89. 1780.

?*Gabura* Adanson, Fam. Pl. 2: 6. 1763?

Scyténium S. F. Gray, Nat. Arrang. Brit. Pl. 1: 398. 1821.

Type species: *Collema Lactuca* (Web.) Wiggers [*Lichen crispus* L.].

Thallus foliose or squamulose to almost crustose, gelified when moist, lying on the substrate without rhizinae, homoeomerous, not corticate, hyphal system loose; algae *Nostoc*. Apothecia at first sunken, erumpent, sessile or scutellate and constricted below, with amphithecium; parathecium either present or absent, both parathecium and hypothecium either of interwoven hyphae or pseudoparenchymatous; paraphyses simple, adherent, mostly septate; asci 8-spored; ascospores colorless, cylindric, acicular, fusiform, long-ellipsoidal or ovoidal to almost cubical, ends obtuse or acute, sometimes becoming muriform, thin-walled, without gelified sheath. Spermatogonia sunken in the thallus or in thalline warts, with light-colored wall; spermatophores simple or branched, without sterigmata, septate with short cells; spermatia short, oblong to ellipsoidal, straight.

KEY TO TROPICAL AMERICAN SPECIES OF COLLEMA

Amphithecium corticate; spores acicular.....COLLEMODIOPSIS

[*C. lherminieri* Hue, from Guadeloupe, is the only species of this typically northern group so far reported. *C. Granadillae* is here reported from Costa Rica.]

Amphithecium not corticate.

Spores oblong to ellipsoidal, more or less muriform; thallus laciniate, more or less granular. **BLENNOTHALLIA**

Lobes less than 0.5 mm. broad; apothecia unknown; Chile. *C. millegranum*

Lobes more than 0.5 mm. broad; apothecia well developed; Mexico. . .

. *C. mexicanum*

Spores clavate, ellipsoidal to fusiform, uniseptate, rarely up to 3-septate, not over 30 μ long; thallus narrowly laciniate or incised. **DICOLLEMA**

Spores clavate, 14–21 x 4.5–5.5 μ ; Brasil, Paraguay, and Argentina. . .

. *C. corynesporum*

Spores ellipsoidal or fusiform.

Margins of laciniae nodose-granular. *C. pycnocarpum*

Spores 6–9 x 3 μ ; Brasil. *v. Minarum*

Spores 10–14 x 3–4 μ ; Brasil. *v. Malmei*

Spores 10–15.5 x 4–5.5 μ ; Brasil and Colombia. *v. crassiusculum*

Spores 14–17 x 4–5 μ ; New York and New Jersey. *v. typicum*

Spores 16–25 x 3–7 μ , 3-septate; Virginia southward. *C. cyrtaspis*

Spores 16–30 x 4–5 μ , 1–3-septate; Chile. *C. pycnocarpoides*

Margins of laciniae not nodose-granular.

Laciniae 1–3 mm. broad, spores 12–14 x 5–6 μ ; Paraguay. *C. crenatum*

Laciniae under 1 mm. broad, more or less canaliculate below; Cuba.

Laciniae thick. *C. stellatum*

Laciniae thin, flat; spores 11–17 x 4–5 μ *C. solenarium*

Spores fusiform to acicular, more than 3-septate, over 30 μ long; thallus broadly laciniate, often fenestrate. **SYNECHOBlastus**

Thallus isidiose; spores over 100 μ in length; Brasil.

Parathecium present, spores 125–175 x 3–4 μ *C. leptosporum*

Parathecium absent, spores somewhat over 100 μ in length. *C. Ramboi*

Thallus not isidiose; spores not over 95 μ in length.

Apothecia white-pruinose.

Apothecia small, crowded on short bullate prominences; spores

50–80 x 3–5 μ ; thallus pustulate, not fenestrate; southern

United States and southward along coastal plains. *C. leucopepla*

Apothecia sessile or nearly so, larger; thallus more or less fenes-

trate; tropical highlands. *C. glaucophthalmum*

Spores 77–92 x 6–7 μ ; Mexico. *v. typicum*

Spores 55–74 x 5–7 μ , 7–11-septate; Colombia. *v. granatense*

Spores 42–58 x 4–5 μ , 6–9-septate; Brasil. *v. brasiliense*

Spores 36–50 x 7 μ , only 5-septate. *C. leucocarpum*

Apothecia not white-pruinose.

Spores 48–66 x 6–8 μ ; Colombia. *C. implicatum*

Spores 38–50 x 6–8 μ ; Chile. *C. chilenum*

Spores 40–45 x 5–6.5 μ ; apothecia sessile, margins turgid; Mex-

ico. *C. turgidulum*

Spores 30–37 x 2.5–3 μ ; apothecial margins thin, blackening;

Brasil. *C. baculiferum*

COLLEMODIOPSIS Vainio, Étude Lich. Brésil 1: 234. 1890.

Type species: *Collema nigrescens* (Huds.) DC.

Spores slender, several-celled phragmospores, never muriform, apothecia with a pseudoparenchymatous cortex.

This subgenus is typically northern in its distribution. Only *C. lherminieri* Hue from Guadeloupe has been described previously from the American tropics.

COLLEMA (COLLEMODIOPSIS) **Granadillae** Dodge, sp. nov.

Type: Costa Rica, Guanacaste, H. Granadilla, *Dodge & Thomas 6576*.

Thallus irregulariter subpinnatifide lobatus, lobis tenuibus, ad 1 mm. latis, viridi-nigricans, superne elevato-rugosus verrucosusque ad subisidiosus, inferne reticulatim elevato-rugosus, cinerascens, ad 400 μ crassitudine, decorticatus, rhizinis destitutus. Apothecium planum, peltatum, basi constrictum, 0.5–1.0 mm. diametro metiens, omnino nigrum, margine verrucosa; amphithecium 150–250 μ crassitudine, pseudoparenchymatice corticatum, intus algis nostocaceis subrectis; parathecium grosse pseudoparenchymaticum, bene evolutum, 100–120 μ crassitudine inferne, attenuatum ad 25–35 μ superne; hypothecium hyphis tenuibus dense contextum, 25–30 μ crassitudine; thecium 150–170 μ altitudine, paraphyses arcte cohaerentes septati, cylindrici, filiformes, ad 1 μ diametro metientes, clavato-capitati; ascosporae octonae, polystichae, rectae, fusiformes vel aciculares, 5-septatae, 37–42 x 4–5 μ .

Thallus irregularly subpinnately lobed, lobes slender, about 1 mm. broad, dark greenish black, with elevated folds and wrinkles above with masses of small subisidiose warts, below reticulately deeply scrobiculate wrinkled, more or less ashy, about 400 μ thick, without cortex or rhizoids. Apothecium peltate with constricted base, plane, about 0.5–1 mm. in diameter, wholly black, margin verrucose; amphithecium 150–250 μ thick, corticate with several layers of pseudoparenchyma below, within the filaments of *Nostoc* more or less straight and loosely interwoven; parathecium of large-celled pseudoparenchyma, about 100–120 μ thick below, thinning above at the margin to 25–35 μ ; hypothecium of densely woven slender hyphae, 25–30 μ thick; thecium 150–170 μ tall; paraphyses closely adherent, septate, cylindrical, filiform, about 1 μ in diameter, clavate, capitate at the apex; ascospores 8 per ascus, polystichous, straight, fusiform or acicular, 6-celled, 37–42 x 4–5 μ .

Guanacaste: H. Granadilla, *Dodge & Thomas 6576*; near Tilarán, *Standley & J. Valerio 44529*, 640–660 m., *Dodge & Thomas 6560*.

COLLEMA LEUCOPEPLA (Tuck.) Schneider, *Guide Study Lich.*, 181. 1898.

Collema nigrescens var. *leucopepla* Tuck., *Syn. N. Am. Lich.* 1: 148. 1882.

Type: not stated in original description, based on material from South Carolina, Georgia, Florida, Alabama, and Louisiana.

It is probable that material collected in Puntarenas, Boruca, 560 m., *Tonduz 5373*, and determined by Müller Argau as *C. nigrescens* var. *caesium* Ach., belongs here but I did not have time to study it critically while I was in Genève. This species of the lower Atlantic and Gulf Coastal Plain in the United States has also been reported by Vainio from Mexico.

DICOLLEMA (Clements) Dodge, n. subgenus.

Dicollema Clements, *Gen. Fung.* 74. 1909.

Type species: *Collema pycnocarpum* Nyl.

Thallus narrowly laciniate or incised, spores clavate to fusiform, typically 2-celled, rarely 4-celled.

The material referred to the type species of this genus by different authors is quite variable and the whole group needs a thorough revision. Pending such a study, I am proposing several varieties of *C. pycnocarpum* Nyl. to cover the more conspicuous variations which seem to have separate geographical ranges, those with the smaller spore sizes being rather more southern in their distribution.

COLLEMA PYCNOCARPUM Nyl., *Syn. Meth. Lich.* 1: 115. 1858.

Type: United States [on journey from New York to Philadelphia], *Moré*.

Thallus dark or pale green, medium in size, granulate-nodose. Apothecia rufous, crowded, almost contiguous, at first plane, then somewhat convex, quite small, 0.5 mm. or a little larger; spores 8 per ascus, oblong or oblong-ellipsoid, simple or uniseptate, 14–17 x 4–5 μ .

Northern Atlantic Coastal Plain.

Var. **Minarum** Dodge, var. nov.

Collema pycnocarpum Vainio, *Étude Lich. Brésil* 1: 238. 1890.

Type: Brasil, Minas Geraes, Sitio, 1000 m., *Vainio 734*.

Sporae oblongae, ellipsoideae vel fusiformes, 1-septatae, 6–9 x 3 μ .

Var. **Malmei** Dodge, var. nov.

C. pycnocarpum Malme, Ark. f. Bot. 19⁸: 7. 1924.

Type: Brasil, Rio Grande do Sul, Canõas near Porto Alegre, *Malme 536*.

Sporae oblongo-ellipsoideae vel ellipsoideae, uniseptatae, 10–14 x 3–4 μ .

Var. **crassiusculum** (Malme) Dodge, comb. nov.

Forma *crassiusculum* Malme, Ark. f. Bot. 19⁸: 7. 1924.

Collema pycnocarpum Nyl., Acta Soc. Sci. Fenn. 7: 428. 1863.

Type: Brasil, Matto Grosso, Corumbà, *Malme*.

Sporae ellipsoideae, utroque apice obtusae, raro acutae vel altero obtusae, altero acutae, 10–15.5 x 4–5.5 μ .

The specimens cited by Nylander from Colombia, Bogotá, 2600 m., *Lindig 2872*, have spores 10–14 x 4.5–5.5 μ .

COLLEMA CYRTASPIS Tuck., Proc. Amer. Acad. Arts & Sci. 5: 387. 1862.

Type: no type mentioned in the original description.

Thallus deeply and irregularly lobed, verrucose, deep blue green, darkening on drying, verrucae much larger than in *C. pycnocarpum*, about 400 μ thick; algal layer about 100 μ thick, composed of coiled and tangled filaments of *Nostoc* imbedded in a gel, cells spherical, about 4 μ in diameter; medulla gelified, traversed by very loosely tangled hyphae about 2–3 μ in diameter and occasional straight filaments of *Nostoc*. Apothecia immersed in the verrucae when young, becoming plane or even convex, up to 2 mm. in diameter, margin slightly verrucose when young, practically disappearing as the apothecium becomes increasingly complex; amphithecium about 160 μ broad, of the same texture as the thallus; parathecium lacking; hypothecium filamentous, quite highly developed, about 40 μ thick, not conspicuously thinner toward the margins, hyphae 2–3 μ in diameter, very loosely woven; thecium about 80 μ tall; paraphyses filamentous, clavate, expanded above, imbedded in a gel; asci clavate, about 40 x 8 μ , 8-spored; ascospores subfusiform, 2–4-locular, 16–25 x 3–7 μ [16–20 x 4–4.5 μ in Costa Rican specimens].

This species is widely distributed in the southern Atlantic

and Gulf Coastal Plain in the United States, extending up the Mississippi Valley to Iowa.

Guanacaste: Liberia, 100 m., *Dodge & Thomas 8016, 8027*.

SYNECHOBLASTUS (Trevis.) Vainio, *Étude Lich. Brésil* 1: 234. 1890.

Lathargium S. F. Gray, *Nat. Arrang. Brit. Pl.* 1: 399. 1821, p. p.

Synechoblastus Trevis., *Caratt. Tre Nuov. Gen. Coll.* 3. 1853, p. p.

Type species: as subgenus based on *C. glaucophthalmum* Nyl.

Apothecia without pseudoparenchymatous cortex, spores fusiform to more or less acicular, many-celled, mostly over 30 μ long.

This subgenus is typically northern. Only two species are known from Costa Rica, where they are temperate species at elevations between 1000 and 1800 m., and are also found in the highlands of Colombia at somewhat greater altitudes.

COLLEMA GLAUCOPHTHALMUM Nyl., *Syn. Meth. Lich.* 1: 114, 115. 1858.

Type: Mexico, Orizaba, *Fr. Müller*.

Thallus olivaceous-fuscous, medium size, expanded, more or less fenestrate and dissected, scrobiculate, and often granuliferous. Apothecia glauco-lilac colored, plane and somewhat concave, margin prominent, thin; ascospores 77–92 x 6–7 μ .

Var. GRANATENSE Hue, *Jour. de Bot. [Morot]* 20: 12. 1906.

Collema glaucophthalmum Nyl., *Acta Soc. Sci. Fenn.* 7: 428. 1863, non loco alio.

Type: Colombia, Choachí, 2600 m., *Lindig 813*.

Thallus dusky yellowish green to almost black, irregularly lobed and fenestrate, smooth or somewhat scrobiculate, coarsely wrinkled and subverrucose, especially toward the tips, margins thick and rounded, 800–1000 μ thick, homoeomerous, of loosely tangled filaments of *Nostoc*, cells 5–6 x 2.5–3 μ , ellipsoidal. Apothecia peltate, constricted at the base, up to 3 mm. in diameter, margin at first prominent, smooth, becoming thinner, less prominent and verrucose at maturity; disc chalky white to vinaceous-russet; amphithecium about 160 μ thick, homogeneous with the thallus; parathecium pseudoparenchymatous, 40 μ thick, thinning to 20 μ or even disappearing above at the margin;

hypothecium filamentous, of large very densely interwoven hyphae about $40\ \mu$ thick; thecium about $120\ \mu$ tall; paraphyses filiform, about $1\ \mu$ in diameter, not swollen above; asci clavate, about $20\ \mu$ in diameter, 8-spored; ascospores polystichous, fusiform to acicular, $55\text{--}74 \times 5\text{--}7\ \mu$.

The whiteness of the apothecial disc is very variable on the same thallus, in general being more pronounced on young and rapidly growing apothecia and gradually disappearing on older and more exposed ones. It seems to be a semi-crystalline deposit which slowly dissolves away, disclosing the vinaceous-russet disc formed by the discoloration of the upper portion of the gel surrounding the paraphyses. This variety has previously been reported only from Colombia.

Cartago: near R. Birris above Santiago, 920–1340 m., *Dodge 8011*, *Dodge & Thomas 8015*; Carpintera, 1700 m., *K. Danielson 102*.

San José: Sta. María de Dota, 1500–1800 m., *Standley & J. Valerio 44150*.

COLLEMA IMPLICATUM Nyl., *Acta Soc. Sci. Fenn.* **7**: 428. 1863.

Type: Colombia, Villeta, 1100 m., *Lindig 749*; Cundinamarca, Bogotá, 2400–2600 m., *Lindig*.

Thallus dark greenish black, broadly lobed and fenestrate, smooth near margins, becoming deeply reticulate-scrubulate in older portions of the thallus, verrucae scattered, more elevated, often subisidioid, margins thin and semipellucid, homoeomerous, of loosely tangled filaments of *Nostoc*, cells $4 \times 5\ \mu$, heterocysts $5 \times 8\ \mu$, much more closely tangled in an outer zone about $150\ \mu$ thick. Apothecia peltate, constricted at the base, up to 4 mm. in diameter, margin at first prominent, verrucose, becoming thinner, less prominent, scarcely visible as the apothecium becomes expanded and convex, disc cameo-brown, without pruina in young apothecia; amphithecium about $100\ \mu$ thick, homogeneous with the thallus; parathecium pseudoparenchymatous, about $80\ \mu$ thick below, thinning out to a single layer of thick-walled cells $6\ \mu$ wide above at the margin; hypothecium of densely woven hyphae about $20\ \mu$ thick; thecium about $100\ \mu$ tall; paraphyses about $2\ \mu$ in diameter, with clavate brown tips; asci clavate, 8-spored, $12\text{--}16\ \mu$ in diameter; ascospores polystichous, fusiform to acicular, $48\text{--}66 \times 6\text{--}8\ \mu$, 7–9-septate.

This species is very closely related to *C. glaucophthalmum*

and has been reduced to synonymy by some authors. It differs from the previous species in several minor details of proportion of measurements and in the lack of a well-developed pruina. It is to be hoped that some one will be able to study the two forms in the field to determine the constancy of this character. In a series of specimens one can find considerable variation in the amount of pruina in *C. glaucophthalmum*. It should be noted that the two species occupy the same areas in Costa Rica.

Cartago: above R. Birris at Santiago, 1140–1180 m., *Dodge 8017*; Carpintera, 1700 m., *K. Danielson 101c*.

The following species has not been found in Costa Rica but it is closely related to this group.

COLLEMA (SYNECHOBLASTUS) **Ramboi** Dodge, sp. nov.

Type: Brasil, Rio Grande do Sul, Porto Alegre, *B. Rambo 74*.

Thallus parvus, adscendens, obscure viridi-nigricans, angustilobatus, fenestratus clathratusque, verrucis elevatis isidioideis, marginibus plus minusve integris, tenuibus, pellucidis, 130–140 μ crassitudine, homoeomerus, filamentis nostocaceis laxè implexis, in zona exteriori 40 μ crassitudine dense contextis, cellulis ad 3 x 6 μ . Apothecium peltatum, basi constrictum, planum, 0.5–0.6 (– 1.0) mm. diametro, margine tenui, verrucosa subcrenulatave, disco obscure castaneo nigroque; amphithecium 20 μ crassitudine, cum thallo homogeneous; parathecium deest; hypothecium 20 μ crassitudine, hyphis tenuibus dense contextum; thecium 160 μ altitudine; paraphyses filiformes, ad 1 μ diametro, apicibus inflatis; asci clavati, 120 x 8–10 μ ; ascosporeae octonae, polystichae, aciculares, immaturae, plus quam 100 μ longitudine, multiloculares.

Thallus small, elevated, dark greenish black, narrowly lobed and fenestrate, verrucae elevated and isidioid, margins more or less smooth, thin, pellucid, 130–140 μ thick, homoeomerous, of loosely tangled filaments of *Nostoc*, cells about 3 x 6 μ , much more closely tangled in an outer zone about 40 μ thick. Apothecia peltate, constricted at the base, 0.5–0.6 (– 1.0) mm. in diameter, plane, margin very thin, verrucose, subcrenulate, finally almost disappearing while the expanded apothecium remains plane, disc dark chestnut to black; amphithecium 20 μ broad, homogeneous with the thallus; parathecium absent; hypothecium 20 μ .

thick, of slender densely woven hyphae; thecium about 160 μ tall; paraphyses filiform, about 1 μ in diameter with greatly swollen tips, imbedded in a hymenial gel; asci clavate, 8-spored, 120 μ long, 8–10 μ wide; ascospores polystichous, 8 per ascus, acicular, immature and very difficult to measure but somewhat more than 100 μ long, many-celled.

LEPTOGIUM S. F. Gray

LEPTOGIUM S. F. Gray, Nat. Arrang. Brit. Pl. 1: 400. 1821.

Type species: *Leptogium tremelloides* S. F. Gray, excl. syn.

Thallus foliose in the tropical species, gelified, below naked (covered with rhizinae in section *Mallotium*), with pseudoparenchymatous cortex above and below, algae *Nostoc*. Apothecia sunken in the thallus at first, emerging and often short-stipitate; amphithecium often corticate with several layers of pseudoparenchyma below, usually of a single layer above; parathecium usually present and pseudoparenchymatous, often thinning out above at the margin, sometimes of large, more or less parallel hyphae; paraphyses simple and filiform, often with apex variously thickened; asci clavate to cylindrical, 8-spored; ascospores usually imbricately monostichous, occasionally distichous, hyaline, usually broadly fusiform with acute to acuminate ends (acicular in section *Leptogiopsis*), usually muriform (except in *Leptogiopsis*), with thin walls.

Four of the seven sections into which *Leptogium* is divided are found in tropical America, all four of them in Costa Rica. *Leptogiopsis* differs from all the other sections in its acicular, never muriform spores, and perhaps should be treated as a separate genus, more or less related to section *Synechoblastus* of *Collema*. It is endemic in tropical America, with a single unidentifiable fragment yet found in Costa Rica. *Mallotium*, to which may also be referred the section *Leptolobaria* of Vainio based on *L. callithamnium* from Chile and the Antilles, has highly developed rhizinae below, and often more or less tomentum above, especially in the vicinity of the apothecia. It is widespread in its distribution, being found in the temperate zones and evidently preferring the colder regions of the tropics, not occurring below about 1300 m., in Costa Rica not seen below 3000 m. *Diplothallus*, with

its two separate layers of thallus, each with its own cortex, connected by pillars of pseudoparenchyma which on drying cause punctate depressions in the thallus, is endemic in tropical America and confined to the temperate regions, in Costa Rica occurring between 1200 and 1700 m., coming down to lower levels in the mountain near H. Santamaría of the Cordillera de Tilarán in Guanacaste. *Euleptogium*, which contains the most species, is found from sea level to about 1800 m. in Costa Rica, although most of the species of this section have a narrower altitudinal range. The lowland species ascend the river valleys but mostly drop out at about 1000 m. These are usually widespread at low elevations, extending from the Atlantic and Gulf Coastal plains of the United States to southern Brasil and Paraguay. The species of the temperate region of Costa Rica are mostly confined to the mountains from southern Mexico to the northern Andes and the mountains of eastern Brasil.

The morphology of the apothecium is not altogether clear and considerable confusion exists in the nomenclature of the various parts. In the following discussion, I have treated the tissue, usually well differentiated, underlying the hypothecium, as the parathecium, whether it extends to the surface of the thecium or not and whether or not it is pseudoparenchymatous. In a very few species the parathecium as thus defined thins out and disappears near the edge of the thecium, and the hyphae of the hypothecium extend up to the surface of the thecium. It is possible that some would prefer to regard the parathecium as formed of two layers, the lower of which is pseudoparenchymatous and the upper filamentous, with only the upper extending to the surface of the thecium. The amphithecium (thalline margin of earlier lichenologists) is essentially homogeneous and continuous with the thallus, although the algae are sometimes more densely tangled and in many species the cortical cells on the under side of the amphithecium (morphologically continuous with the upper surface of the thallus) or even the under side of the thallus below the apothecium, may proliferate, forming a pseudoparenchyma of several layers of cells sometimes even thicker than the algal zone.

KEY TO THE TROPICAL AMERICAN SPECIES OF LEPTOGIUM

Spores acicular, never muriform.

Thallus reticulate-scribulate; French Guiana. [Spores 6-celled, 35 x 10 μ , teste Leighton, in specimen from Amazonas, Brasil].....*L. reticulatum*

Thallus not reticulate-scribulate.

Spores 48 μ long, 8-10-celled; Florida.....*L. fusisporum* (Tuck.) Dodge

Spores 50-60 x 7-8 μ , 10-12-celled; Mexico.....*L. adpressum*

Spores 65-85 x 3.5-5 μ , 10-12-celled; Brasil.....*L. megapotamicum*

Spores muriform.

Thallus of two lamellae, each with its own cortex, attached to each other by columns of tissue.....**DIPLOTHALLUS**

A single species.....*L. diaphanum*

Thallus of a single lamella, not as above.

Thallus with a thick tomentum of rhizinae below.....**MALLOTIUM**

Apothecia on lower surface, lobes of thallus broad, imbricate....*L. resupinans*

Apothecia on upper surface.

Upper surface of thallus tomentose, at least near apothecia.

Margins of sinuses inrolled, lobes medium, sinuate; apothecial margins microphylline.....*L. inflexum*

Margins of thallus isidiose dissected.

Upper surface of thallus subglabrous and more or less granular-papillate.....*L. papillosum*

Upper surface of the thallus arachnoid-tomentose, lobes minutely dissected, not otherwise isidiose; Chile.*L. callithamnium*

Upper surface of thallus glabrous except in the vicinity of the apothecia; apothecial margin isidiose, scattered groups of isidia sometimes on the upper surface of the thallus.
.....*L. inflexum* v. *isidiosulum*

Thallus corticate with a single layer of cells on both surfaces, without rhizinae.....**EULEPTOGIUM**

Thallus scribulate.

Margin of thallus papillate-denticulate, olivaceous, thallus deeply reticulate-scribulate; parathecium filamentous; spores 22-24 x 12-14 μ*L. olivaceum*

Margin of thallus smooth, thallus plumbeous.

Thallus deeply reticulate-scribulate; spores 30-40 x 12-16 μ .
.....*L. foveolatum*

Thallus shallowly scribulate; spores 20-30 x 8-10 μ ...*L. microstictum*

Thallus variously wrinkled on drying, but not scribulate, usually nearly smooth when moist.

Apothecia on tips of long swollen processes of the thallus.

Thallus lobes narrow, dichotomously branched, wrinkles irregular.....*L. stipitatum*

Thallus lobes broader, not conspicuously dichotomously branched, wrinkles predominantly longitudinal or radial, secondary wrinkles mostly periclinal to margins.

Apothecia radially wrinkled to smooth; spores 23-32 x 10-13 μ*L. vesiculosum*

Apothecia with periclinal wrinkles, foliolate or isidiose.

Thallus and apothecia not isidiose.

- Apothecia small, spores $22-30 \times 10-12 \mu$, margin wrinkled.
 Thallus lobes broad.....*L. phyllocarpum*
 Thallus lobes narrower, margins crisped.....*v. campestre*
 Apothecia rather large with more or less foliolate margins.
*v. macrocarpum*
 Thallus and apothecia isidiose, often densely so; spores
 $30-40(-45) \times 12-17 \mu$*L. coralloideum*
 Apothecia marginal, sessile or on short solid stalks, very minute.
 Thallus dark green to black, exciple isidiose [spores $24-30$
 $(-33) \times 12-14 \mu$, transverse septa 5, fide Malme];
 Jamaica.....*L. chloromelan*
 Thallus ashy to plumbeous.
 Exciple isidiose, parathecium 150μ thick; thecium $150-$
 180μ tall.....*L. marginellum*
 Exciple verruculose, parathecium 100μ thick; thecium
 $120-140 \mu$ tall; Paraguay.....*L. pilcomayense*
 Exciple crenulate, parathecium 30μ thick; thecium $110-$
 130μ tall; Paraguay.....*L. microcarpum*
 Apothecia scattered on upper surface of the thallus.
 Thallus thick, 250μ or more, roughened below by more or
 less conical outgrowths but rhizinae absent.
 Smooth above or slightly wrinkled, lobes ascending, obo-
 vate; Mexico.....*L. hypotrachynum*
 Reticulately wrinkled above, lobes appressed, short, wide,
 margins sometimes crisped; Brasil.....*L. mattogrossense*
 Smooth or only slightly wrinkled below.....*L. sessile*
 Thallus thinner, seldom reaching 200μ .
 Thallus more or less isidiose.
 Isidia blackening, cylindric; parathecium well developed.
 Spores $18-23 \times 8-10 \mu$, transverse septa 3, rarely 5;
 Brasil and Paraguay.....*L. pichneum* Malme excl. syn.
 Spores $22-30 \times 11-13 \mu$, transverse septa 5.....
*L. simplicius v. pichneoides*
 Isidia concolorous, parathecium not well developed....
*L. denticulatum* Nyl.
 Thallus 100μ thick; apothecia not isidiose; spores
 $22-27 \times 7-9 \mu$, transverse septa usually 5; isidia
 coralloid branched or somewhat flattened; Brasil.
*L. austroamericanum* (Malme) Dodge
 Thallus about 30μ thick; apothecial margins verrucose,
 spores $16-23 \times 8-9 \mu$, transverse septa 3; isidia
 often flattened and microphylline.....
*L. denticulatum* Malme non Nyl.
 Isidia of hemispheric concolorous granules, thallus rigid,
 irregularly undulate, wrinkled toward the margin;
 Paraguay.....*L. granulare*
 Thallus not isidiose.
 Parathecium filamentous, or, if pseudoparenchymatous,
 very thin and inconspicuous.

- Cortex of amphithecium a single layer of cells; thallus 50–75 μ thick; apothecia rarely 1 mm. in diam.; spores 15–19 x 6–8 μ with 3 transverse septa; Brasil.....*L. Puiggarii*
- Cortex of amphithecium a single layer of cells above, becoming thick, pseudoparenchymatous below; apothecia 1–3 mm. in diam.
- Thallus greenish black, 80–100 μ thick; spores 15–22 x 6–8 μ , with 3–5 transverse septa; Brasil...*L. brasiliense*
- Thallus ashy, plumbeous, or bluish.
- Thallus papulose and wrinkled above, opaque, 130–160 μ thick; spores 20–30 x 7–12 μ ...*L. pulchellum*
- Thallus minutely wrinkled above, opaque, 150–170 μ thick; spores 24–28 x 12 μ*L. Standleyi*
- Thallus minutely wrinkled above, margins in-rolled; spores 38–46 x 16–18 μ*L. dimorphum*
- Thallus smooth or minutely wrinkled on drying, pellucid, less than 100 μ thick.
- Spores 22–28 x 8–10 μ ; thecium 120–150 μ tall; thallus 80–100 μ thick.....*L. azureum*
- Spores 18–22 x 10–12 μ , with 3–5 transverse septa; thecium 90–120 μ tall; thallus 35–60 μ thick.....*L. Tuckermanni*
- Spores 18–24 x 8–9 μ with 3–5 transverse septa; thecium 140–160 μ tall; thallus 35–50 μ thick; Brasil.....*L. Schiffneri*
- Parathecium pseudoparenchymatous.
- Spores 35–40 x 16–20 μ ; thallus plumbeous to greenish; amphithecium smooth; Bolivia.....*L. laevius* (Nyl.) Dodge
- Spores 30–40 x 12–17 μ ; thallus rather dark plumbeous to black.
- Laciniae 1–1.5 mm. broad, apothecia not over 1.5 mm. in diam.; thecium 170 μ tall; paraphyses 1.5–2 μ thick; Brasil....*L. Lafayetteanum*
- Laciniae up to 8 mm. broad, apothecia 1–2.5 mm. in diam.; thecium 190–220 μ tall; paraphyses 2.5–3 μ thick; Brasil.....*L. pachycheilum*
- Spores 25–35 x 12–15 μ ; apothecia 1–2.5 mm. in diam.; thecium 150–180 μ tall; paraphyses 2–2.5 μ thick; Brasil.....*L. ulvaceum* Malme non Pers.
- Spores 22–30 x 11–13 μ ; apothecia 1.5–2.2 mm. in diam.; thecium 150–170 μ tall.....*L. simplicius*
- Spores 18–34 x 9–15 μ ; thallus dark green to plumbeous; amphithecium granulate to wrinkled.
- Thalline lobes ascendant, gyrose-plicate. .*L. conchatum* (Tuck.) Dodge
(*L. chloromelan* auct. non Sw.)
- Thalline lobes narrower, edges erect, crisped. *L. stellans* (Tuck.) Dodge
- DIPLOTHALLUS Vainio, Étude Lich. Brésil 1: 222. 1890.
- Thallus of two lamellae connected by pillars. Each lamella

has a cortex of a single layer of isodiametric cells above and below, drying impressed-punctate. Rhizinae absent, spores muriform.

LEPTOGIUM DIAPHANUM (Sw.) Mont., Ann. Sci. Nat. Bot. III, 10: 134. 1848.

Lichen diaphanum Sw., Nov. Gen. Sp. Pl. Prodr. 147. 1788.

Parmelia diaphana Ach., Meth. Lich. 223. 1803.

Collema diaphanum Ach., Lichenog. Univ. 654. 1810.

Leptogium punctulatum Nyl. ap. Fournier, Mexic. Pl. 1: 1. 1872.

Leptogium tremelloides var. *impressopunctatum* Tuck. ap. Williams, Amer. Nat. 29: 482. 1895.

Type: Jamaica, Swartz, in Riksmuseet, Stockholm, carefully described by Malme, Ark. f. Bot. 19^s: 27. 1924.

Thallus mineral gray, lobes rounded, ascending, crowded, impressed-punctate, otherwise quite smooth, consisting of two layers, each about 40 μ thick, composed of a row of pseudoparenchymatous cells about 8 μ in diameter on each surface and an algal layer of *Nostoc* between, the layers connected by pseudoparenchymatous pillars whose contraction in drying form the depressions. Apothecia borne on the upper layer, peltate, constricted at the base, 1–1.5 mm. in diameter, margin light buff, smooth, disc chestnut; amphithecium corticate with thick pseudoparenchyma below, about 80 μ thick, thinning to two layers of cells above next the disc, algal layer about 30 μ thick below the thecium; parathecium absent; hypothecium of densely woven, large, thick-walled hyphae about 50 μ thick; thecium 120–130 μ tall; paraphyses filiform, 1–2 μ thick, with clavate tips, forming a brown epithecium imbedded in a gel; asci clavate to cylindric, about 12–16 μ in diameter, thin-walled tips thickened and staining deep blue with iodine; spores 8 per ascus, imbricately monostichous, fusiform, muriform, 16–25 x 7–8 μ , with 3–5 transverse septa.

This species is found in the mountains from Mexico and the West Indies, Dominican Republic, and Jamaica (900–1200 m.) to Minas Geraes (1400–1500) m., Bolivia (1900 m.), and Perú (1700 m). In Costa Rica it is found from 1200 to 1700 m. and descends to 800 m. on the mountain back of the farmhouse at

H. Santamaría where the peculiar weather conditions enable many species to flourish below their normal altitudes. Apparently it needs high humidities as it is found mostly in localities of frequent and long-continued fogs (see p. 379).

Cartago: R. Birris above Santiago, 1220–1340 m., *Dodge & Thomas 7933*; Cartago, *R. Torres R. 143*; Carpintera, 1700 m., *K. Danielson 103*.

San José: Sta. María de Dota, 1500–1800 m., *Standley & J. Valerio 43208*.

Heredia: C. Central de Zurquí, 1600–1700 m., *Dodge, J. Valerio & Thomas 4624*.

Guanacaste: H. Santamaría, 720–850 m., *Dodge, Jiménez & Thomas 7017*.

MALLOTIUM Ach., Lich. Univ. 644. 1810.

Mallotium Gray, Nat. Arrang. Brit. Pl. 1: 399. 1821

Type: *Collema saturninum* (Dicks.) Ach.

Thallus foliose, cortex of pseudoparenchyma above, below tomentose with rhizinae; spores muriform.

This subgenus, considered as a separate genus by many authors, is cosmopolitan in distribution, mostly along cold foggy coasts or in mountains, being abundant in species in northern Europe and in Patagonia, Tierra del Fuego, and Antarctic Islands. Our tropical species seem confined to much higher elevations (above 1800 m. in Costa Rica) than the other members of *Leptogium*. It is quite distinct in appearance, often tomentose above, so that sterile specimens might be taken for *Erioderma* or *Umbilicaria* on macroscopic examination.

Our two species, *L. inflexum* and *L. papillosum*, are both Mexican, the former extending to Perú, the latter not known south of Costa Rica.

LEPTOGIUM **papillosum** (Bouly de Lesdain) Dodge, comb. nov.

Leptogium Hildenbrandii var. *papillosum* Bouly de Lesdain, Lich. Mexique, 30. 1914.

Type: Mexico, Michoacan, Puebla, H. Batan, *G. Arsène Brouard 4212*; Morelia, C. Azul, *G. Arsène Brouard 3999*.

Thallus mineral gray above, dark olive buff below, lobes subpinnatifid, with small, lacerate, almost isidioid margins, papillate-granulose, sometimes isidiose above, densely tomentose below, algal layer about 60 μ thick, corticate on each surface, with cells 5–6 μ in diameter, the cortex of the lower surface giving rise to a dense covering of rhizinae. Apothecia submarginal but too immature in our specimens to show details of structure well.

San José: L. de la Chonta, n. e. Sta. María de Dota, 2000–2100 m., *Standley 42285*; near Sta. María de Dota, 1500–1800 m., *Standley 41643*.

LEPTOGIUM INFLEXUM Nyl., *Flora* 41: 377. 1858; *Syn. Meth. Lich.* 1: 132. 1858.

Type: Mexico, Orizaba, *Fr. Müller*.

Thallus deep glaucous gray, dark olive buff below, lobes irregular, rounded, margins crisped and subascending, smooth above except in the vicinity of the apothecia, densely tomentose below, algal layer about 60 μ thick, corticate on both sides with two layers of cells about 8–10 μ in diameter, the lower surface giving rise to rhizinae, as also the outer cortical cells in the vicinity of the apothecia. Apothecia large, up to 4 mm. in diameter, margin more or less tomentose below, phylloporous, concolorous with the thallus, disc orange rufous to auburn, edge of parathecium lighter; amphithecium with pseudoparenchymatous cortex about 100 μ thick, thinning to about one or two cells thick above, algal layer of *Nostoc* about 80 μ thick; parathecium pseudoparenchymatous, about 20 μ thick below the hypothecium, expanding upward to thickness of 100 μ above; hypothecium 30 μ thick, of densely woven hyphae; thecium 240 μ tall; paraphyses filiform, 1–2 μ in diameter, with swollen clavate tips forming a brown epithecium; asci 20–25 μ in diameter, cylindrical; ascospores monostichous, 8 per ascus, broad, fusiform, muriform, with 7 transverse septa, about 35–40 x 13–17 μ .

Superficially the thallus suggests the texture of *L. tremelloides*, while the apothecia might easily be mistaken for *L. phyllocarpum*, although the rhizinae below should be easily observed.

Cartago: F. Volcán de Turrialba, 2000–2400 m., *Standley 34966, 35174*.

San José: Quebradillas, 7 km. n. Sta. María de Dota, *Standley 42899*; C. de las Vueltas, 2700–3000 m., *Standley & J. Valerio 43823a*.

Var. ISIDIOSULUM Nyl., *Acta Soc. Sci. Fenn.* 7: 429. 1863; *Ann. Sci. Nat. Bot.* IV, 19: 289. 1863.

Type: Colombia, Paramo Choachí, 3600 m., *Lindig*.

This variety differs in the thallus being partly isidio-furfuraceous, especially the margins of the lobes; apothecial margin isidiose instead of phylloporous, subnude below; spores 36–44 x 18–25 μ .

This variety would seem to differ from *L. papillosum* in that the isidia are in scattered groups or marginal, much more highly

developed and more denuded below. A single sterile specimen has been referred here.

San José: C. Zurquí, 2000–2500 m., *Standley & J. Valerio 48292*.

EULEPTOGIUM Tuck., Gen. Lich. 95. 1872.

Stephanophorus Fw., *Linnaea* 17: 29. 1843.

Type species: no species cited.

Thallus foliose, monophyllous, without rhizinae, upper and lower cortex present, each of a single layer of isodiametric cells; spores muriform, many-celled.

This subgenus is predominantly tropical with many species in tropical America.

LEPTOGIUM OLIVACEUM (Hook.) Zahlbr., Cat. Lich. Univ. 3: 146. 1924, excl. syn.

Collema olivaceum Hook. ap. Kunth, Syn. Pl. Aequinoct. Orb. Nov. 1: 38. 1822.

Type: Colombia, Cauca, between Popayan and Almaguer, *Humboldt 252*.

Thallus isabella to light brownish olive, lobes broad and rounded, surface deeply reticulate-scrobiculate with sharp ridges and margins granulate-isidiose, or ridges rarely microphylline; about 200 μ thick, corticate above and below with an algal layer of loosely tangled filaments of *Nostoc* corresponding to a medulla, separated from the cortex by a palisade layer about 30 μ thick. Apothecia sessile, margin verrucose, concolorous, disc darker; amphithecium thick, homogeneous with the thallus; parathecium about 80 μ thick, of very densely woven hyphae; hypothecium about 25 μ thick, very deeply staining; thecium about 100 μ tall; paraphyses filiform, about 1.5 μ in diameter, ending in the epithelial gel.

The apothecia are very rare and too immature in the one specimen from Costa Rica to give all the characters, but it seems quite distinct from *L. reticulatum* and *L. foveolatum*.

Cartago: R. Reventazón below Santiago, 740–750 m., *Dodge 8010*.

Var. **granulosum** Dodge, var. nov.

Type: Costa Rica, San José, R. Virilla below El Brazil, *Dodge 8030*.

Thallus similis speciei sed nigro-granulatum ambobus superficiebus. Apothecia obscure brunnea, nigricantia, sessilia, basi

constricta, disco concolore; amphithecium 190 μ crassitudine, corticatum cellulis isodiametricis; parathecium 130–140 μ crassitudine, ad marginem 40 μ attenuatus, hyphis dense contextum; hypothecium 30 μ crassitudine; thecium 120–130 μ altum; paraphyses similes speciei; asci 12–16 μ diametro metientes; ascospores imbricatim monostichae, octonae, fusiformes, 22–24 x 12–14 μ .

Thallus similar to that of the species but black-granulate on both surfaces. Apothecia dark brown, blackening, sessile, constricted at the base, disc concolorous; amphithecium 190 μ thick, homogeneous with the thallus, corticate with a single layer of isodiametric cells; parathecium 130–140 μ thick, thinning toward the margin to 40 μ , of densely woven hyphae; hypothecium 30 μ thick, so deeply staining that its structure is not clear; thecium 120–130 μ tall; paraphyses as in the species; asci cylindric, 12–16 μ in diameter; ascospores imbricately monostichous, 8 per ascus, fusiform, 22–24 x 12–14 μ .

San José: R. Virilla below El Brazil, *Dodge 8030*.

LEPTOGIUM FOVEOLATUM Nyl., Syn. Meth. Lich. 1:124. 1858.

Type: not stated, specimens from Bolivia, *Weddell*, and Mexico, *Fr. Müller*, are mentioned.

Thallus mineral gray or darker, often discolored light yellowish olive or darker, lobes rounded, smooth, surface deeply foveolate with sharp wrinkles both above and below; very variable in thickness up to 250 μ , *Nostoc* very sparsely scattered throughout, rather denser and tending to form a palisade layer just below the surface, but this layer much thinner and less definite than in *L. olivaceum*. Apothecia about 1.5 mm. in diameter, constricted at the base, margin smooth, light buff, disc cinnamon rufous; amphithecium about 130 μ thick, similar to the thallus in structure but algae much more abundant and closely tangled and cortex pseudoparenchymatous, about 50 μ thick; parathecium about 40 μ thick below, thinning out and disappearing above, pseudoparenchymatous with small cells; hypothecium about 80 μ thick, very deeply staining; thecium about 170 μ tall; paraphyses filiform, about 2 μ in diameter, tips clavate; asci 8-spored, cylindrical, about 12 μ in diameter; ascospores imbricately

monostichous, 30–40 x 12–16 μ [only 20 x 10 μ in Costa Rican specimens, but obviously immature].

San José: R. Virilla below El Brazil, *Dodge 7783*.

LEPTOGIUM MICROSTICTUM Vainio, *Dansk Bot. Ark.* 4¹¹: 18. 1926.

Type: not stated, specimens cited, Mexico, Palenque, *Liebmann 7415, 7416, 7428*; Papantla, *Liebmann*.

Thallus light glaucous blue or a little darker, lobes rounded, surface smooth but irregularly impressed, margin thin and smooth; about 225 μ thick, corticate on both surfaces with cells about 4 μ in diameter, the filaments of *Nostoc* very loosely tangled, more or less parallel to the surface and very scanty in the middle. Apothecia 0.5–1.0(–1.3) mm. in diameter, sessile, constricted at the base, margin thin, whole, concolorous with the thallus, disc pale to tawny; amphithecium about 60 μ thick, cortex pseudoparenchymatous, about 25 μ thick below, thinning out above to a double layer of cells, algal layer of tangled filaments of *Nostoc*; parathecium pseudoparenchymatous, about 40 μ thick, thinning above to about three layers of cells; hypothecium 30 μ thick, of densely tangled rather large hyphae suggesting pseudoparenchyma but cells much smaller than in the parathecium; thecium about 100 μ tall; paraphyses filiform, 1 μ in diameter, ending in the epithecial gel; asci clavate to cylindrical, 12–16 μ in diameter; ascospores distichous, 8 per ascus, fusiform, with about 5 transverse septa, 20–30 x 8–10 μ .

A single small specimen from Costa Rica is doubtfully referred here. The thallus is somewhat more finely impressed and occasionally near the margin it appears very minutely scrobiculate. This specimen is from a greater elevation than most other members of this subgenus.

San José: Guayabillos and Cabeza de Vaca, 2150–2350 m., *Dodge & Thomas 7418*.

LEPTOGIUM VESICULOSUM (Sw.) Malme, *Ark. f. Bot.* 19^s: 14–15. 1924.

Lichen vesiculosus Sw., *Nov. Gen. Sp. Pl. Prodr.* 147. 1788.

Lichen bullatum Ach., *Lichenog. Suec. Prodr.* 137. 1798.

Leptogium bullatum Mont., *Ann. Sci. Nat. Bot.* II, 16: 113. 1841.

Type: Jamaica, tops of mountains, *O. Swartz*. *L. bullatum* Ach. based on the same material.

Thallus plumbeous, lobes rounded, more or less appressed, longitudinally wrinkled with shallower cross ridges; about 100 μ thick between the ridges, corticate on each surface with a single layer of isodiametric cells, homoeomerous, of very loosely tangled filaments of *Nostoc* running more or less parallel to the surface. Apothecia sunk in the tips of podetiiform elevations of the thallus, margin wrinkled but not isidioid or phylloporous, edge of parathecium conspicuous light buff, disc concave, rufous; amphithecium continuous with the thallus without differentiation, cortex a single layer of cells both above and below; parathecium 100 μ thick below, thinning out to 40–60 μ above at the margin, pseudoparenchymatous; hypothecium thick, 80 μ , of densely woven slender hyphae; thecium 120–140 μ tall; paraphyses slender, filiform, cells almost isodiametric above, disintegrating into the brown epithelial gel; asci cylindrical, 20 μ in diameter, 8-spored; ascospores imbricately monostichous, broadly fusiform, 23–32 x 10–13 μ , with 5 transverse septa.

This species seems to be widespread in the American tropics, from 700 to 2100 m., rarely also below these levels. *L. stipitatum*, with which this species is easily confused, seems confined to the lower levels, reaching up to about 800 m., and has so far only been reported from Guadeloupe and Costa Rica.

Limón: Waldeck, *Dodge & Nevermann* 7938; Marta, 20 m., *Dodge* 7427.

Cartago: Angostura, *Polakowsky* 456; Juan Viñas, 1000 m., *Calvert* 68; Santiago, 1140–1180 m., *Dodge* 4555; R. Birris, 1220–1340 m., *Dodge & Thomas* 4628; Aguacaliente, 1240–1460 m., *Dodge & Thomas* 7082; Carpintera, 1700 m., *K. Danielson* 101a.

San José: S. Pedro de Montes de Oca, 1200 m., *Thomas* 4717; S. Juan Tibas, 1000–1100 m., *Dodge* 4303.

Guanacaste: H. Santamaría, 640–680 m., *Dodge & Thomas* 6797.

Puntarenas: Boruca, 560 m., *Tonduz* 5380.

Var. *DIGITATUM* Eschw. ap. Martius, Fl. Brasil. 1: 238. 1833.

Collema bullatum Raddi, Atti Soc. Ital. 18: 36, pl. 4, f. 2.

Collema bullatum var. *dactylinoideum* Nyl., Flora 41: 338. 1858; Syn. Meth. Lich. 1: 129. 1858.

Type: Brasil, between Mandioca and Morro do Frade, *Raddi*, type of var. *dactylinoideum* not cited, but specimens from Mexico, *Fr. Müller*, Colombia, Tolima, *Goudot*, and Bolivia, *Weddell*, are mentioned.

This variety is stated by Eschweiler to have a thicker thallus,

deep green instead of lead color, densely wrinkled instead of granular; podetia cylindrical instead of ventricose, 6–12 mm. instead of 2–6 mm. tall, about 6 mm. in diameter.

From the description this variety does not seem distinct from the species and I have seen no material referable here from Costa Rica. It is possible that Eschweiler was attempting to separate this species from *L. phyllocarpum* which he called *Collema (Leptogium) bullatum* var. *sertatum*.

LEPTOGIUM STIPITATUM Vainio, *Hedwigia* 38: (255). 1899.

Type: Guadeloupe Island, near Gourbeyre, *P. Duss* 434.

Thallus plumbeous, soon discolored buffy citrine to Saccardo's olive, irregularly dichotomously branched, ultimate lobes 2–7 mm. broad, then crowded and confluent, rounded, acutely and irregularly wrinkled above and below; about 200 μ thick between the ridges, with *Nostoc* filaments densely coiled and tangled near the surface, mostly parallel to the surface within, much more abundant than in *L. vesiculosum*, with cortex of isodiametric cells on each surface. Apothecia on short thalline pustules, up to 2.5 mm. in diameter, margin thick with periclinal folds (never radial as in *L. vesiculosum*), disc chestnut; amphithecium about 200 μ thick, of the same texture as the thallus; parathecium 80 μ thick, disappearing above, of large-celled pseudoparenchyma; hypothecium 80 μ thick, of more or less parallel hyphae continued upward as a false parathecium; thecium about 140 μ tall; paraphyses filiform, about 1.5 μ in diameter, septate, with capitate tips in the brown epithecial gel; asci cylindrical, 16–20 μ in diameter; ascospores distichous, broad-fusiform with acute ends, 24–32 x 10–12 μ .

San José: cañon of R. Virilla, below El Brazil and Sta. Ana, *Dodge* 8019.

Puntarenas: Peninsula of Puntarenas, 3–5 m., *Dodge* 8021.

LEPTOGIUM PHYLLOCARPUM (Pers. ap. Gaudich.) Mont., *Ann. Sci. Nat. Bot.* III, 10: 134. 1848.

Collema phyllocarpum Pers. ap. Gaudich. in Freycinet, *Voy. Uranie, Bot.* 204. 1826.

Collema bullatum var. *sertatum* Eschw. ap. Martius, *Fl. Brasil.* 1: 239. 1833.

Type: Brasil, Rio de Janeiro, *Gaudichaud*.

Thallus plumbeous but frequently becoming black, especially

in specimens which have been dried slowly or repeatedly wetted and dried after collection, lobes broad, surface deeply and acutely wrinkled, the wrinkles predominantly longitudinal or radial, the secondary wrinkles very irregular; more than 200 μ thick between the wrinkles, corticate on both surfaces by a single layer of isodiametric cells, the filaments of *Nostoc* loosely tangled, more or less parallel to the surface and much more coiled and densely tangled just under the upper cortex. Apothecia about 2 mm. in diameter, margin with crowded periclinal wrinkles, disc rufous, immersed in hollow protuberances as in *L. vesiculosum*; amphithecium appearing lobed in section up to 500 μ thick, homogeneous with the thallus but algae a little denser; parathecium about 100 μ thick below, thinning out to about 20 μ above at the margin, of large-celled pseudoparenchyma; hypothecium about 30 μ thick, of slender densely woven hyphae continuing up to the margin at about the same width; thecium about 140 μ tall; paraphyses filiform, not dilated above, epithelial gel brown; asci cylindric, about 20 μ in diameter, 8-spored; ascospores broad-fusiform with acute ends, monostichous, with 5 transverse septa, 22-30(-35) \times 10-12(-14) μ .

Apparently this species is very widespread and common in the American tropics from low elevations in the southern United States to 2500 m. in Perú. In Costa Rica it ranges from 500 m. to about 1900 m., being characteristic in the moister fog-bathed areas of the temperate region.

Cartago: Santiago, 1140-1180 m., *Dodge 8000*; R. Birris, 1220-1340 m., *Dodge & Thomas 7994*.

San José: Cañon of R. Virilla below El Brazil, *Dodge 7782*; Zapote, 1200 m., *Standley 40273*; La Palma, 1500-1700 m., *Maxon & Harvey 7891*; Quebradillas, near Sta. María de Dota, 1800 m., *Standley 42977*; Sta. María de Dota, 1500-1800 m., *Standley 42424*; S. Marcos de Dota, 1200 m., *Tonduz 5374*; R. Naranjo, *Tonduz 5375*; S. Gabriel, *Tristan 5229*; S. José, *Polakowsky 113*.

Alajuela: R. Ciruela, 920-980 m., *Dodge & J. Valerio 4858*; Santiago de S. Ramón, 1000 m., *Brenes*; Viento Fresco, 1600-1900 m., *Standley & Torres 47771*.

? Puntarenas: Corozal, 5-50 m., *Dodge 8025*.

Var. MACROCARPUM Nyl., Syn. Meth. Lich. 1: 130. 1858.

Type: not cited but specimens from Aequatorial America, *Humboldt*, Chile, Perú, and Venezuela, *Lind. 1092*, are mentioned.

Similar to the species but apothecia large, 5-9 mm., margins lobulate, foliose. American material referred to var. *daedaleum*

Nyl. probably belongs here. Distribution in Costa Rica essentially similar to that of the species but not yet collected in the higher elevations.

Cartago: Santiago, 1140–1180 m., *Dodge 8001*; R. Birris, 1220–1340 m., *Dodge & Thomas 4632*; Carpintera, 1700 m., *K. Danielson 101b*.

San José: R. Naranjo, *Tonduz 5377*.

Alajuela: La Palma de San Ramón, 1250 m., *Brenes 91*.

Guanacaste: H. Santamaría, 640–780 m., *Dodge & Thomas 6776, 8002*; Tilarán, 500–690 m., *Standley & J. Valerio 44803, Dodge & Thomas 6562*.

Puntarenas: Corozal, 5–50 m., *Dodge 7529*.

Var. CAMPESTRE Malme, Ark. f. Bot. 19⁸: 13. 1924.

Type: Brasil, Bahia, R. Vermelho, *Malme 29, 30*; Matto Grosso, Cuyaba, *Malme 2715c*, etc.; Serra da Chapada, pr. Bocca da Serra, *Malme 2245B*.

Differs from the typical form by narrower crowded lobes, margins crisped; apothecia 1–2 mm. in diameter, margin rugulose, thin; amphithecium corticate with a single layer of cells; parathecium 60–70 μ thick, reaching the margin above; thecium 100–125 μ tall, asci up to 20 μ thick, 8-spored; ascospores irregularly distichous, broad-fusiform, acute ends, 22–27 \times 8–10 μ , usually with 5 transverse septa.

San José: Turrúcares, 540–600 m., *Dodge & Thomas 7481*.

Alajuela: R. Ciruela, 920–980 m., *Dodge & J. Valerio 7921*; Santiago de S. Ramón, 1000 m., *Brenes*.

LEPTOGIUM CORALLOIDEUM Vainio, Ann. Acad. Sci. Fenn. A 6⁷: 110. 1915.

Leptogium diaphanum f. *coralloideum* Mey. & Fw., Nova Acta Acad. Leopold. Carolin. 19: Suppl. 226. 1843.

Leptogium phyllocarpum var. *isidiosum* Nyl., Syn. Meth. Lich. 1: 130. 1858.

Leptogium phyllocarpum var. *coralloideum* Hue, Nouv. Arch. Museum Paris III, 10: 228. 1898.

The type of var. *isidiosum* is from Mexico, Orizaba, *Fr. Müller*.

Thallus as in *L. phyllocarpum* but densely isidiose, especially along the wrinkles, somewhat thicker, semi-pellucid. Apothecia large when present, very rare, margin densely coralloid-isidiose, disc rufous; amphithecium highly developed, homogeneous with the thallus; parathecium 140 μ thick, disappearing above, of large thin-walled pseudoparenchyma; hypothecium 60 μ thick, reaching the margin above, of densely woven slender hyphae;

thecium 200 μ tall; paraphyses filiform with clavate apices; asci cylindrical; ascospores 8 per ascus, imbricately monostichous, ellipsoid to fusiform, apices acute, 30–40(–45) \times 12–17 μ , with 7 transverse septa.

This species is perhaps only a large isidiose variety of *L. phyllocarpum*, essentially similar in morphology but larger in most dimensions. It occupies the same general region as *L. phyllocarpum*. It is usually sterile and hence not easily distinguished from sterile *L. marginellum* var. *isidiosellum*. Material has been seen from Mexico, Perú, and Brasil.

Limón: Hamburg, 20–30 m., Dodge 7420.

Cartago: Pejivalle, 650–900 m., Standley & J. Valerio, Dodge & Thomas 4337; Cañon of R. Reventazón below Santiago, 920–1000 m., Dodge & Thomas 8013, Dodge 8004; R. Birris, 1220–1340 m., Dodge & Thomas 7954; C. Carpintera, 1320–1700 m., Dodge 3758, Dodge & Thomas 4762, K. Danielson 98; Aguacaliente, 1240–1460 m., Dodge & Thomas 8003; R. Reventado, 1460–1650 m., Standley & J. Valerio 49614.

San José: R. Virilla below El Brazil, Dodge 6496; Zurquí, 1600–2500 m., Standley & J. Valerio 48255, 48266, 48146, Dodge, J. Valerio & Thomas 6042.

Alajuela: near Fraijanes, 1500–1700 m., Standley & Torres 47425, 47462.

Guanacaste: H. Santamaría, 640–680 m., Dodge & Thomas 8005; Tilarán, 500–650 m., Standley & J. Valerio 44367, 44403.

LEPTOGIUM MARGINELLUM (Sw.) S. F. Gray, Nat. Arrang. Brit. Pl. 1: 401. 1821.

Lichen marginellus Sw., Nov. Gen. Sp. Pl. Prodr. 147. 1788.

Collema vesicatum Taylor, London Jour. Bot. 6: 196. 1847.

Leptogium corrugatulum Nyl., Syn. Meth. Lich. 1: 132. 1858.

Type: Jamaica, Blue Ridge Mt., Swartz. The type of *C. vesicatum* Taylor is from St. Vincents, West Indies. The type of *Leptogium corrugatulum* is from Mexico, Jalapa, Galeotti 9630.

Thallus plumbeous, round-lobed, margin smooth or occasionally microphylline, pellucid, surface of undulating longitudinal wrinkles less acute than in *L. phyllocarpum*, of variable thickness, about 160 μ thick, corticate on both surfaces with small isodiametric cells. Apothecia minute, up to 0.3 mm. in diameter, margin densely isidiose, disc rufous; amphithecium thick, with pseudoparenchymatous cortex below, a single layer of cells above, as are also the isidia; parathecium 150 μ thick, pseudoparenchymatous; thecium 150–180 μ tall, epithecium tawny; asci 8-spored; spores imbricately monostichous, ellipsoid-fusiform, ends acute, 25–35 (–40) \times 10–13 μ , with 5 transverse septa.

This species rarely matures spores although rudimentary apothecia are nearly always abundant. The microscopic details of the apothecium are largely taken from Malme as I have seen no mature asci in my Costa Rican material. There is considerable variation in the amount of isidia, as they easily break off leaving minute foveoles on the margin. The species is quite distinct and is widespread in the American tropics. I have seen material from Florida, Alabama, Bermuda, various islands of the West Indies, Mexico, Brasil, and the Galápagos Islands. It seems to range from sea level to 1500 m.

From the nature of the isidia it seems likely that var. *isidiosellum* Riddle, Brooklyn Bot. Gard. Mem. 1: 115. 1918, should be referred to *L. coralloideum*, although sterile isidiose states are very difficult to place.

Limón: Marta, 20 m., *Dodge & Nevermann 7986*; Carmen, *Dodge 7422*; Waldeck, *Dodge & Nevermann 7421*.

Cartago: Pejivalle, 600–900 m., *Dodge & Thomas 8014*, *Standley & J. Valerio 46769*; R. Birris, 920–1100 m., *Dodge 7988*; Santiago, 1140–1180 m., *Dodge 7987*; Aguacaliente, 1240–1460 m., *Dodge & Thomas 7937*; Carpintera, 1500 m., *Dodge 3948*.

Alajuela: Santiago de S. Ramón, 1000 m., *Brenes 242*; S. Pedro de S. Ramón, 700 m., *Brenes*.

Guanacaste: H. Santamaría, 640–720 m., *Dodge & Thomas 6867*, *7989*; H. Grana-dilla, above R. S. José, 480 m., *Dodge & Thomas 7936*; H. Q. Azul, on lower slope of V. Tenorio, 400–600 m., *Dodge & Thomas 6653*; Tilarán, 500–690 m., *Dodge & Thomas 6561*.

Puntarenas: R. Terrones, 30 m., *Dodge & Marks 7980*; Corozal, 5–50 m., *Dodge 7533*.

LEPTOGIUM DENTICULATUM Nyl., Ann. Sci. Nat. Bot. V, 7: 302. 1867.

L. tremelloides v. *leptophyllum* Mey. & Fw., Nova Acta Acad. Leopold. Carolin. 19: Suppl. 228. 1843.

L. tremelloides v. *azureum* f. *isidiosum* Müll. Arg., Bull. Soc. R. Bot. Belg. 29: 49. 1891, non Flora 65: 292. 1882.

L. leptophyllum Zahlbr., Cat. Lich. Univ. 3: 136. 1924.

Type: Colombia, San Jil, 1300 m., *Lindig*.

Thallus mineral gray or darker, large, broadly lobed, lobes round, edges smooth, somewhat crisped, surface slightly wrinkled, 100–120 μ thick, microphylline, isidiose, corticate on both sides with a single layer of cells, the short filaments of *Nostoc* with cells 4–5 μ in diameter mostly assembled just under the cortex,

leaving the central portion relatively free of algae. Apothecia relatively rare but when present usually numerous, scattered over the upper surface, up to 2 mm. in diameter, margin granular, thick, becoming isidiose in age, buff, disc rufous; amphithecium 220 μ thick, with a layer of pseudoparenchymatous cortex below about 160 μ thick, not thinning out much above and merging with the parathecium, algal layer 60 μ thick below, thinning out to 30 μ above; parathecium 100 μ thick below, thinning out to about 40 μ above, of large thin-walled hyphae at times suggesting pseudoparenchyma; hypothecium 20 μ thick, of more slender deeply staining hyphae; thecium 160 μ tall; paraphyses slender, ending abruptly in the epithelial gel; asci 10–12 μ in diameter, cylindrical, 8-spored; ascospores imbricately monostichous, fusiform with acute ends and about 5 transverse septa, about 24 x 10 μ .

This species seems widespread in the American tropics, although it is so rarely fertile that it is difficult to be sure of the determination of much of the sterile material, especially to separate it from *L. cyanescens* var. *austro-americanum* Malme. As here described, this species is close to, although not identical with, Malme's variety, while the *L. denticulatum* Malme seems to be an isidiose state of or closely related to *L. Tuckermanni*. Only a careful comparison of all the fertile specimens from tropical America in the various herbaria of Europe can settle these problems.

Limón: Marta, 20 m., *Dodge & Nevermann 7428*; Hamburg, *Standley & J. Valerio 48750*; Castilla, 20 m., *Dodge & Nevermann 7996*; Waldeck, *Dodge & Nevermann 7997*, *Dodge 8012*.

Cartago: R. Reventazón below Santiago, 740–750 m., *Dodge 4626*, 920–1000 m., *Dodge & Thomas 7993*; Santiago, 1100–1140 m., *Dodge 7939*; R. Birris, 1220–1340 m., *Dodge & Thomas 7992*; Estrella, 1600 m., *K. Danielson 162*; near Cartago, 1500 m., *K. Danielson 22*; C. Carpintera, 1500 m., *Dodge 3973*.

San José: San José, *Tonduz 5247*.

Heredia: C. Zurquí, 1600–1700 m., *Dodge, J. Valerio & Thomas 8048*.

Alajuela: C. Mondongo de S. Ramón, 750–800 m., *Brenes 275*; Alto de la Palma de S. Ramón, 1250 m., *Brenes 377*.

Guanacaste: H. Santamaría, 680–780 m., *Dodge & Thomas 6870, 7014*; H. Grana-dilla above R. Las Cañas, 500–600 m., *Thomas 6623*.

Puntarenas: Osa, Corozal, 5–50 m., *Dodge 7998*.

LEPTOGIUM AZUREUM (Sw.) Mont. ap. Webb, Hist. Nat. Îles Canaries 3¹: 129. 1840.

Lichen azureum Sw. ap. Ach., Lichenog. Suec. Prodr. 137. 1798.

Type: mountains of Jamaica, *O. Swartz*.

Thallus pellucid, greenish-glaucous-blue to puritan gray, broadly sinuate-rounded lobes, smooth; margins smooth, 80–100 μ thick, of loosely coiled and tangled filaments of *Nostoc* with ellipsoidal cells 2.5 x 4 μ . Apothecia scattered, 1–2 mm. in diameter, margin smooth, light buff, disc rufous, sessile or on a short stalk; amphithecium 320 μ thick, below with a pseudo-parenchymatous cortex about 100 μ thick, above with a single layer of isodiametric cells in the cortex; parathecium filamentous, 40 μ thick, poorly developed, of slender hyphae not reaching the margin; hypothecium 20 μ thick, deeply staining; thecium 120–150 μ tall; paraphyses filiform, 1.5–2 μ thick, thickened at the tips to about 4 μ ; asci clavate-cylindrical, about 18 μ in diameter, 8-spored; ascospores imbricately monostichous or somewhat distichous, fusiform ends acute, with 3 or 5 transverse septa, 22–28 x 8–10 μ .

Only a careful study of all the types involved can settle nomenclature of the group of species centering around *L. tremelloides*. This species was originally collected in South Africa by Thunberg, and very briefly described by Linné fil. The early lichenologists of the west coast of Europe identified their material as this species and later reduced Swartz' Jamaican *L. azureum* to synonymy. There is apparently a whole group of species having approximately the same macroscopic appearance but wholly different microscopic structure which are at present referred to this species by various workers. As we have here defined it (agreeing closely with *L. tremelloides* Malme), it is a species of the lowlands coming up the river valleys under favorable conditions to about 1000 m. in Costa Rica. It seems widely distributed at lower elevations in tropical America.

Limón: Marta, 20 m., Dodge & Nevermann 7414, 7426; Hamburg, 20–30 m., Dodge & Nevermann 7417; Castilla, 20 m., Dodge 7209, 7419, 7424; Carmen, Dodge 7415; Indiana I. near Siquirres, 60–70 m., Dodge & Thomas 5572; along R. Siquirres, 70–350 m., Dodge, Catt & Thomas 8006, 8007, 8008; Livingston, 80–100 m., Dodge, Catt & Thomas 5573; Waldeck, Dodge & Nevermann 7412, 7413, 7416; Guápiles, 300–500 m., Standley 37137.

Cartago: Turrialba, Ørsted; R. Pejivalle, 650–800 m., Dodge & Thomas 4414; R. Reventazón, 920–1000 m., Dodge & Thomas 4604.

Guanacaste: H. Santamaría, 760–900 m., *Dodge & Thomas 6876*; Tilarán, 500–690 m., *Dodge & Thomas 8009*.

Puntarenas: Osa, C. Guaca, 85 m., *Dodge 7505*; Corozal, 5–50 m., *Dodge 7530*.

Isla Coco: *Snodgrass & Heller*.

LEPTOGIUM *Standleyi* Dodge, sp. nov.

Leptogium tremelloides Auct., non Linné fil.

Type: Costa Rica, La Hondura, *Standley 37870*.

Thallus plumbeus, crassus, laevis vel minute rugulosus, lobis rotundatis, latis, marginibus integris, 150–170 μ crassitudine, filamentis nostocaceis sub cortice dense implicatis, centro laxe aut sparse implicatis, corticatum e serie simplice cellularum. Apothecia ad 3 mm. latitudine, plana, margine integro, tenui, laevi, fulva, disco rufo; amphithecium inferne 160 μ , ad 100 μ crassitudine superne in margine attenuatum, cortice pseudo-parenchymatico, 90 μ crassitudine inferne ad una serie cellularum superne attenuatum, filamentis nostocaceis dense contextum; parathecium 60 μ crassitudine, hyphis tenuibus dense contextum; hypothecium flavum, 20–30 μ crassitudine, hyphis tenuibus dense contextum; thecium ad 180 μ altitudine; paraphyses filiformes, tenues, apice non incrassata; asci cylindrici, 20 μ diametro metientes; ascosporae octonae, imbricatim monostichae vel distichae, fusiformes, 24–28 x 12 μ .

Thallus mineral gray or darker, thick, smooth or minutely and shallowly wrinkled, lobes broad, rounded, margins smooth, 150–170 μ thick, filaments of *Nostoc* densely tangled next the cortex, loosely tangled and scattered in the center of the thallus, cortex of a single series of cells on both surfaces. Apothecia 3 mm. broad, plane, margin smooth, thin, tawny, disc rufous; amphithecium 160 μ thick below, thinning to 100 μ above at the margin, corticate below, 90 μ thick, pseudoparenchymatous, above becoming a single layer of cells, filaments of *Nostoc* densely tangled; parathecium 60 μ thick, of slender more or less parallel hyphae; hypothecium yellowish, 20–30 μ thick, of slender densely woven hyphae; thecium 180 μ tall; paraphyses filiform, slender, apices not thickened; asci cylindrical, 8-spored, 20 μ in diameter; ascospores imbricately monostichous or distichous, fusiform, 24–28 x 12 μ .

This species is essentially close to *L. azureum* in its microscopic characters but differs in its much larger dimensions, its thicker,

opaque thallus, and larger apothecia. Superficially it somewhat resembles *L. pulchellum* but is much less coarsely wrinkled and differs in microscopic details. In Costa Rica it seems to be confined to the higher elevations reaching 1700 m. It is probable that material determined as *L. pulchellum* from Costa Rica by Müller Argau belongs here, although I did not have time to section it. It certainly is not typical *L. pulchellum*.

Cartago: Turrialba, Ørsted; Orosl, 1000–1100 m., *Standley* 39791.

San José: San José, 1130 m., *Standley* 41233; La Hondura, 1300–1700 m., *Standley* 37870, TYPE.

Alajuela: Poás, *Tonduz* 5301.

LEPTOGIUM Tuckermani Dodge, sp. nov.

Leptogium tremelloides var. *minor* Tuck. in herb.

? *Leptogium moluccanum* Vainio, Étude Lich. Brésil 1: 223–224. 1890, non *Collema moluccanum* Pers. ap. Gaudich. in Freycinet, Voy. Uranie, Bot. 203. 1826.

Type: Cuba, Monte Verde, *C. Wright* 56.

Thallus plumbeus vel obscurior, lobis confertis, rotundatis, superne inferneque sat laevigatus, tomento isidiisque destitutus, tenuissimus, 35–60 μ crassitudine, strato nostocaceo 25 μ , corticibus pseudoparenchymaticis cellulis magnis. Apothecium minutum, 0.5–0.9 mm. diametro metiens, peltatum, basi constrictum, margine integro, pallescente, disco castaneo; amphithecium corticatum cellulis pseudoparenchymaticis, 60 μ crassitudine inferne, attenuatum ad 12 μ superne, strato nostocaceo 40 μ crassitudine; parathecium pseudoparenchymaticum tenue, 10–12 μ crassitudine, cellulis parvis; hypothecium 20 μ crassitudine, hyphis tenuibus dense contextum; thecium 90–120 μ altitudine; paraphyses filiformes, 2 μ diametro, apicibus incrassatis; epi-thecium brunneum; asci cylindrici, 12 μ diametro metientes; ascosporae octonae, imbricatim monostichae, apicibus acutis, murales, septis transversalibus 3–5, cellulis haud numerosis, 18–22 x 10–12 μ .

Thallus mineral gray or darker, lobes crowded, more or less elevated and crisped, rounded, smooth on both sides, 35–60 μ thick, algal layer of *Nostoc* about 25 μ , with pseudoparenchymatous cortex above and below of large cells. Apothecia minute, 0.5–0.9 mm. in diameter, constricted at the base, margin whole, smooth, pale, disc chestnut; amphithecium with a thick pseudo-

parenchymatous cortex below, about 60 μ , thinning to two rows of cells about 10–12 μ thick above; parathecium thin, pseudoparenchymatous, 10–12 μ thick, of small cells, inconspicuous and often reported absent; hypothecium 20 μ thick, of slender densely woven hyphae; thecium 90–120 μ tall; paraphyses filiform, 2 μ in diameter, with clavate apices; epithecium brown; asci cylindric, 12 μ in diameter; ascospores 8 per ascus, imbricately monostichous, ends acute, muriform, with 3–5 transverse septa, cells not numerous, 18–22 x 10–12 μ .

This species has long been confused with *L. moluccanum*, *L. Mariannum*, and *L. diaphanum*. It differs from the two former in habit and color and from the latter by its structure. It is apparently widespread in the American tropics, being reported from Paraguay, and from Brasil in the states of Rio Grande do Sul and Matto Grosso by Malme, and in Minas Geraes by Vainio.

Limón: Hamburg, Dodge 7425.

Cartago: Pejivalle, 680 m., Dodge & Thomas 4556; Santiago, 1140–1180 m., Dodge 4555, 8044; Las Concavas, 1350–1450 m., Dodge 6842.

San José: hills above Sta. Ana, Dodge 7781.

Guanacaste: H. Santamaria, 680–780 m., Dodge & Thomas 8043; H. Granadilla, 480 m., Dodge & Thomas 8045.

LEPTOGIUM SIMPLICIUS Vainio, Ann. Acad. Sci. Fenn. A67: 109. 1915.

Type: S. Domingo, La Cumbra, *C. Raunkiaer*.

Thallus between light drab and light grayish olive, with irregularly incised lobes 5–7 mm. broad, not isidiose, with slightly undulate elevated acute wrinkles on both surfaces, corticate with a single layer of isodiametric cells. Apothecia broadly adnate, constricted at the base, sessile, 1.5–2.2 mm. in diameter, disc plane, rufous, margin thin, smooth, lighter than the thallus; amphithecium 140–150 μ thick, corticate with a single series of cells above, pseudoparenchymatous below, 90–100 μ thick; parathecium 120 μ thick below, thinning out to 20 μ thick at the margin above, pseudoparenchymatous; hypothecium filamentous, 30 μ thick; thecium 150–170 μ thick; paraphyses filiform, tips somewhat thickened in the brownish epithecial gel; asci cylindric, 14–16 μ in diameter, 8-spored; ascospores imbricately monostichous, fusiform, thin-walled, with 5 transverse septa, 22–30 x 11–13 μ .

This species previously reported only from the type locality has yet been found only at low elevations on the Pacific slope.

San José: Turrúcares, 540–600 m., *Dodge & Thomas 8047*.

Guanacaste: Liberia, 100 m., *Dodge, Alfaro & Thomas 6586*, *Dodge & Thomas 8028*, Tilarán, 500–690 m., *Dodge & Thomas 8046*.

Var. *pichneoides* Dodge, var. nov.

Type: Costa Rica, Guanacaste, H. Santamaría, *Dodge & Thomas 8029*.

Thallus isidiosus, marginibus microphyllinis aut isidiosis. Apothecium margine tenuiore, laevi, thecium 130–150 μ altitudine.

Thallus isidiöse, margins varying from dentate to short isidiöse or slightly microphylline. Apothecia with thinner, smooth margins, thecium 130–150 μ tall.

Only the type has been found fertile and here there are very few apothecia. The other collections cited probably belong here, but it is always difficult to determine sterile isidiöse specimens in this genus.

Alajuela: R. Ciruela, 920–980 m., *Dodge & J. Valerio 4894*.

Guanacaste: H. Santamaría, 640–680 m., *Dodge & Thomas 8029*.

Besides the species cited above, a single small fragment was found which seems to belong in *Leptogiopsis*, but more material is necessary for a satisfactory disposition.

PANNARIACEAE

Thallus squamose or foliose, not gelified; hypothallus and rhizinae usually highly developed, heteromerous, cortex of erect, irregular or periclinal hyphae, usually more or less pseudo-parenchymatic; medulla well developed, with *Nostoc*, *Scytonema*, or *Dactylococcus*; lower cortex of thick-walled periclinal hyphae often thin or wholly absent. Apothecia marginal or scattered over the upper surface, biatorine or lecanorine; paraphyses unbranched; asci 8-spored; spores hyaline, unicellular, rarely 2–4-celled; spermatia short, straight.

This family seems to be of southern origin with some genera confined to the southern hemisphere, while a few species come northward until they are circumpolar. In general, the northern species are much smaller and more depauperate than the southern species.

In many ways the family seems very homogeneous, so that

genus distinctions are often rather arbitrary. Hue, in 1912, reduced the whole family to a single genus, but his sections and subsections correspond more or less closely to the genera of earlier workers. Zahlbruckner has recognized twelve genera, although the generic delimitation is not altogether clear. Following this treatment I have tentatively recognized seven genera from Tropical America. *Psoroma*, with *Dactylococcus* algae, is largely confined to the southern hemisphere, and by many authors has been placed in the Lecanoraceae. *Lepidocollema*, with a thin upper cortex and almost homoeomerous, is very close to the Collemaeae and is known from a single collection in Brasil. The other five genera are much better known and widespread in the American tropics.

The morphology of the thallus is not altogether clear and the nomenclature of the parts is rather confusing. In the ideal case, the uppermost layer of the thallus, here called "tomentum," is a mass of loosely woven hyphae formed by proliferation of deeper layers. In *Erioderma* it is soft and spongy, like a loose felt, while in *Malmella* and in some of the isidiose members of *Pannaria* it has the appearance of a fine blotting paper, or in *Coccocarpia* the hyphae are more conspicuously parallel and conglutinate, suggesting a frayed cotton yarn. In some species of each genus the tomentum is partly evanescent, or occasionally it is conglutinated into spines or warts. Below the tomentum is an upper cortex of pseudoparenchyma, usually formed by the partial disintegration of a palisade of large thick-walled hyphae which occasionally penetrate between the algal filaments. In *Coccocarpia* the pseudoparenchyma is thin and scarcely distinguishable from the tomentum or even absent. The algal zone varies from a dense palisade of filaments of *Scytonema* and hyphae in some species, to ellipsoidal colonies of *Nostoc* surrounded by hyphae. The medulla in most genera consists of loosely tangled hyphae, occasionally not even well differentiated from the algal layer, while in *Coccocarpia* it is formed of septate periclinal hyphae, scarcely to be distinguished from the lower cortex except in color and the size of the intercellular spaces. The lower cortex may be completely absent or consist of one or more layers of thick-walled periclinal hyphae which give rise to

tufts of rhizinae. The so-called hypothallus in most species is a thick dense mat of rhizinae, which may be absent in *Erioderma*, or occasionally only slightly developed in certain species of the other genera.

The morphology of the apothecium is equally confusing. In *Pannaria* and *Malmella* an amphithecium is present, usually with a pseudoparenchymatous cortex, and a thin algal layer which may be separated from the parathecium by a thin medulla. The parathecium is pseudoparenchymatous, formed from thick-walled periclinal hyphae in *Lepidocollema*, *Parmeliella*, *Coccocarpia*, *Erioderma*, and the smooth species of *Pannaria*, while in the isidiose species of *Pannaria* and in *Malmella* the parathecium is filamentous, in the former of large thin-walled cells, in the latter of slender hyphae. The hypothecium is differentiated somewhat in the species of *Pannaria* but practically undifferentiated in the other genera. Instead of the above interpretation those with a filamentous parathecium might be conceived as lacking a parathecium and having a somewhat highly developed hypothecium, or perhaps the so-called parathecium is really only a compact medulla of the amphithecium. Further study of the morphology of the developmental stages, also more representatives of some of the genera, are necessary before the correctness of any interpretation can be assured.

KEY TO THE TROPICAL AMERICAN GENERA OF PANNARIACEAE

- Thallus with Chlorophyceae; apothecia lecanorine, rhizinae little developed or absent; Perú.....*Psoroma cinchonarum*
- Thallus with Myxophyceae; rhizinae usually well developed.
 - Upper cortex thin, pseudoparenchymatous, algal layer occupying most of the thallus; apothecia biatorine; Brasil.....*Lepidocollema carassense*
 - Upper cortex well developed, pseudoparenchymatous.
 - Upper cortex of two or more rows of cells; hyphae perpendicular to the surface, medulla loosely woven.
 - Apothecia lecanorine.
 - Tomentum absent or very early evanescent, algae definitely *Nostoc*, colonies usually separate; parathecium usually pseudoparenchymatous.....*Pannaria*
 - Tomentum thin but persistent, algae *Nostoc*? or perhaps *Scytonema*; parathecium of slender hyphae.....*Malmella*
 - Apothecia biatorine, pseudoparenchymatous from periclinal hyphae.
 - Tomentum absent, algae *Nostoc*; rhizinae well developed....*Parmeliella*
 - Tomentum present and highly developed, algae *Scytonema* or *Nostoc*; lower cortex little developed; apothecia large, marginal.....*Erioderma*

Upper cortex of septate periclinal hyphae which may simulate pseudoparenchyma, tomentum usually absent; apothecia biatorine, medulla of periclinal conglutinate hyphae appearing pseudoparenchymatous, algae *Scytonema*.....*Coccocarpia*

PANNARIA Del. ap. Bory

PANNARIA Del. ap. Bory, Dict. Class. Hist. Nat. 13: 20. 1828.

Type species: *Pannaria rubiginosa* (Thunberg ap. Ach.) Del. ap. Bory.

Thallus granular, squamose to foliose with a well-developed bluish black or black hypothallus, rarely with dark, more or less tangled rhizinae below, heteromerous, upper surface corticate with large-celled pseudoparenchyma formed from a palisade of hyphae; algae *Nostoc*, medulla single or double, in the former case arachnoid, in the latter the upper portion of more or less parallel, thin-walled hyphae, loosely woven, and below of densely tangled hyphae, without lower cortex. Apothecia at first sunk in the thallus, finally sessile or peltate, superficial; amphithecium pseudoparenchymatous with a few algae in the center; hypothecium hyaline; asci clavate, 8-spored; ascospores hyaline, elongate, ellipsoidal to almost fusiform with a somewhat thickened and finely verrucose wall. Spermatogonia in hemispherical warts, spermatophores septate with short, broad cells; spermatia straight or very slightly curved, elongate, cylindrical.

This genus seems one of the most variable and widespread of the family, occurring from the Arctic to the Antarctic, in Costa Rica occurring from sea level to 1700 m.

In tropical America the genus separates easily into two sections, the isidiose species with a filamentous parathecium, and the smooth species with a pseudoparenchymatous parathecium.

KEY TO THE TROPICAL AMERICAN SPECIES OF PANNARIA

Hypothallus not well developed, pale with pale rhizinae below.

Thecium 80–100 μ or less tall; parathecium filamentous; hypothecium not differentiated; spores 11–12 x 4–5 μ , more or less constricted at the middle and appearing 2-celled; S. Africa.....*P. rubiginosa*

Thecium 100–120 μ or more tall; parathecium of septate hyphae; hypothecium pseudoparenchymatous; spores 13–16 x 7–9 μ ; Rio Grande do Sul, Brasil [*P. rubiginosa* Malme non aliorum].....*P. Malmei*

Hypothallus developed, sometimes sparingly.

Hypothallus pale, thallus squamulose, pale olivaceous to rusty yellow, margin cut-crenate, irregularly lobulate; spores 8–9 x 2.5–3 μ ; Mexico.

.....*P. applanata*

Hypothallus black.

Thallus isidioid.

Margins and surface with cylindrical, coralloid branched isidia; spores 14–19 x 7–8.5 μ ; Antilles and Brasil.....*P. stylophora*

Margins isidio-lacinulate; spores 8–10 x 5–6 μ , with thick episore; Minas Geraes, Brasil.....*P. isidioidea*

Margins with verruciform isidia, lobes under 1 mm. broad; apothecia 1–1.5 mm. in diam.; spores 12–14 x 8–10 μ , wall thin and smooth.*P. Moseni*

Thallus without isidia or soredia.

Thallus livid fuscous, radiately broad-lobed; spores 14 x 6 μ ; hypothallus less developed, center glebulose-lobed; São Paulo, Brasil.

.....*P. imbricatula*

Thallus pallid or ashy or pale glaucous, lobes subcuneate, up to 2 mm. broad; spores 12–15(–18) x 8–9(–10) μ ; parathecium and hypothecium pseudoparenchymatous.....*P. Vainii*

Thallus coerulesco-ashy, lobes cuneate obovate; epithecium black aeruginous; spores 12–20 x 7–8 μ , surface subpubescent; São Paulo, Brasil.....*P. caerulesco-nigricans*

Thallus livid glaucous or lurid pallid, laciniae very distinctly radiate-stellate, even subimbricate.....*P. radiata*

Thallus pale fuscous, lobes 2–2.5 mm. broad and about 6 mm. long; epithecium rufous; spores 12–19 x 8–10 μ ; parathecium pseudoparenchymatous; hypothecium of conglutinate vertical hyphae; Brasil.....*P. brasiliensis*

PANNARIA ISIDIOIDEA Vainio, Ann. Acad. Sci. Fenn. **A67**: 102. 1915.

Pannaria Mariana var. *isidioidea* Vainio, Étude Lich. Brésil **1**: 206. 1890, excl. syn.

Type: Brasil, Minas Geraes, Sitio, 1000 m., *Vainio* 669, 983 (sterile). The following description is based on fertile specimens from Costa Rica.

Hypothallus of dark green rhizinae extending only slightly beyond the thallus; thallus dark olive buff, margins lighter, surface very minutely tomentose, pinnatifid dissected, lobes somewhat cuneate, about 1 mm. wide, ultimate lobules rounded, 0.25–0.5 mm. broad, toward center becoming microphylline and subisidiose but isidia somewhat flattened, rarely cylindric, 150–160 μ thick, upper 40 μ of pseudoparenchymatous cortex, algal layer of *Nostoc* about 40 μ thick, and medulla 40 μ thick, of loosely woven hyphae with occasional small chains of *Nostoc*; rhizinae thick-walled, black, 6–8 μ in diameter. Apothecia crowded, peltate, constricted at the base, about 1 mm. in diameter, margin prominent, crenulate, almost lobulate, disc

chestnut; amphithecium $200\ \mu$ thick, of the same texture as the cortex and algal layer of the thallus; parathecium $60\ \mu$ thick, filamentous, of large thin-walled periclinal hyphae, ending above in a false pseudoparenchyma; hypothecium about $20\ \mu$ thick, of similar structure but more deeply staining; thecium $80\text{--}100\ \mu$ tall; paraphyses slender, filiform, somewhat clavate above in the brownish epithecial gel; asci clavate, $12\ \mu$ in diameter; ascospores ellipsoidal with a thick episore, $8\text{--}10 \times 5\text{--}6\ \mu$ (perhaps still immature).

This species is somewhat variable in appearance and perhaps should be separated into varieties and forms but I have not seen sufficient material to do so properly. Sterile material has been referred here solely on the structure of the thallus. *Dodge & Thomas 6558* from Tilarán has a white reticulate cortex.

Cartago: R. Birris, 1220–1340 m., *Dodge & Thomas 4559*.

Heredia: C. Central de Zurquí, 1600–1700 m., *Dodge, J. Valerio & Thomas 6048*.

Alajuela: Piedades de S. Ramón, 900 m., *Brenes 375*.

Guanacaste: H. Santamaría, 640–680 m., *Dodge & Thomas 6823, 6911, 6988*; Tilarán, 500–690 m., *Dodge & Thomas 8059, 6558*.

Var. pulvinata Dodge, var. nov.

Type: Costa Rica, Alajuela, C. de Pata de Gallo a S. Rafael de S. Ramón, 1200–1250 m., *Brenes*.

Thallus ut in *P. isidioidea* sed isidiosissimus, marginibus adscendentibus, cinerascentibus; isidia coralloidea, elongata, pulvinum formantia.

Thallus as in *P. isidioidea* but densely isidiose with ascending, cinerascant margins; the isidia coralloid, repeatedly branched, crowded, forming a cushion up to 2 cm. in diameter and 3–4 mm. thick.

This variety might easily be mistaken for a sterile pulvinate *Stereocaulon* or a *Siphula*, were it not for the occasional lobe at the margin which shows its relationship.

Alajuela: C. de Pata de Gallo a S. Rafael de S. Ramón, 1200–1250 m., *Brenes*.

PANNARIA Moseni Dodge, sp. nov.

Pannaria rubiginosa Malme, Ark. f. Bot. 20³: 7–8. 1924, pro parte.

Type: Brasil, São Paulo, Sororocaba near Santos, *Mosen 3284*.

Thallus albidus, subpinnatifidus, lobis 3–5 mm. longitudine, 0.8 mm. latitudine, apicibus rotundatis, marginibus loborum

verrucosis, vel etiam in centro thalli isidiosus, ad 140 μ crassitudine, cortex superior 30–35 μ crassitudine, pseudoparenchymaticus ex hyphis perpendicularibus formatus, zona nostocacea coloniis subsphericis 35 μ diametro metientibus, medulla ad 60 μ crassitudine hyphis laxè implexis, rhizinae brunneo-nigricantes, hyphis nigris pachydermaticis 3–4 μ diametro, conglutinis. Apothecia 1–1.5 mm. diametro, marginibus tenuibus, crenato-lobatis et subisidiosis; amphithecium inferne 120 μ crassitudine superne ad 60 μ attenuatum, cortice 40 μ crassitudine, pseudoparenchymatico; parathecium bene evolutum, inferne 40 μ superne ad 60 μ crassitudine, hyphis ad 4 μ diametro leptodermaticis contextum; hypothecium 25 μ crassitudine, hyphis periclinalibus dense compactum; thecium ad 100 μ altitudine; paraphyses filiformes 1–2 μ diametro apicibus clavatis; asci clavati, 25 μ diametro; ascospores octonae, distichae, 12–14 x 8–10 μ , episporio tenuiusculo.

Thallus pearl gray, subpinnatifid, lobes 3–5 x 0.8 mm., with rounded tips, margins of lobes verrucose or even occasionally cylindric, isidiose toward the center, about 140 μ thick, upper cortex 30–35 μ , pseudoparenchymatous from the breaking up of a palisade layer, algal zone of subspherical colonies of *Nostoc* about 35 μ in diameter, medulla about 60 μ thick, of loosely woven hyphae; rhizinae of brownish black thick-walled conglutinate hyphae 3–4 μ in diameter. Apothecia 1–1.5 mm. in diameter, margins thin, crenate-lobulate or even somewhat isidiose; amphithecium about 120 μ thick below, thinning to about 60 μ above with a cortex about 40 μ thick of pseudoparenchyma; parathecium well developed, about 40 μ below, spreading to 60 μ above, of interwoven thin-walled hyphae about 4 μ in diameter; hypothecium about 25 μ thick of dense periclinal hyphae, staining very deeply; thecium about 100 μ tall; paraphyses filiform, 1–2 μ in diameter, with clavate tips; asci clavate, 25 μ in diameter, 8-spored; ascospores distichous, 12–14 x 8–10 μ , with a somewhat thinner episporium.

It is with some hesitation that I have described this species as new. The thallus is very suggestive of the sterile *P. stylophora*, although it has a somewhat different color and lobing and rather larger dimensions of the parts. It does not seem to be closely

related to *P. rubiginosa*, originally described from Thunberg's South African collections, and is certainly not closely related to the material referred to that species in the North Temperate zone. So far I have only seen this species from the Atlantic Coastal Plain of Costa Rica.

Limón: Hamburg, *Standley & J. Valerio 48702, 48717*; R. Siquirres, 70–200 m., *Dodge, Catt & Thomas 8037*.

PANNARIA STYLOPHORA Vainio, Ann. Acad. Sci. Fenn. A67: 102. 1915.

Type: Antilles, Guadeloupe, Sofaga, *P. Duss 1387* (sterile).

Hypothallus black, extending slightly beyond the thallus; thallus with pale olive gray margins and olive gray center, lobes long, slender, oblong, 0.5–0.8 mm. wide, and primary lobes about 15 mm. long, irregularly more or less pinnatifid, smooth above around the margin, the center with scattered to crowded cylindrical isidia which are rarely dichotomously branched, and concolorous, about 125 μ thick, upper cortex 20–25 μ , pseudo-parenchymatous from the development of a palisade layer; algal layer about 40 μ thick, consisting of ellipsoidal colonies of *Nostoc* about 30 x 40 μ ; medulla about 60 μ thick, loosely woven; lower cortex absent; rhizinae of black thick-walled hyphae about 3–4 μ in diameter.

Limón: R. Siquirres, 70–200 m., *Dodge, Catt & Thomas 8036*.

PANNARIA *Vainii* Dodge, sp. nov.

Pannaria rubiginosa Vainio, Étude Lich. Brésil 1: 204–205. 1890; Malme, Ark. f. Bot. 20³: 7–8. 1924, quoad spec. *Dusenianum*.

Type: Brasil, Minas Geraes, Sitio, 1000 m., *Vainio 606*.

Hypothallus black, extending 1–2 mm. beyond thallus; thallus between olive buff and smoke gray, irregularly and repeatedly lacinate, lobes 1–2 mm. broad, ultimate lobes short, broader ones up to 4 mm. long, smooth above, not isidiose, about 160–170 μ thick, upper cortex 20–30 μ thick of 2–3 layers of large isodiametric cells; algal layer of spherical to ellipsoidal colonies of *Nostoc* about 60–65 μ in diameter, algae rather large and somewhat angular by mutual pressure, medulla about 80 μ thick of large, thin-walled hyphae, loosely interwoven; rhizinae of black, thick-walled, conglutinate hyphae. Apothecia peltate, 0.8–2

mm. in diameter, margin thick, crenulate, disc rufous; amphithecium 130–440 μ thick, with cortex 20–30 μ thick; parathecium well developed, about 60 μ thick of periclinal large, thin-walled, hyphae simulating pseudoparenchyma; hypothecium about 20 μ thick, of similar structure but of more slender less frequently septate hyphae; thecium 90–100 μ tall; paraphyses 1.5–2.5 μ in diameter, filiform, slightly clavate at the tips in a yellowish brown epithelial gel; asci 14–16 μ in diameter, 8-spored; ascospores distichous, broadly ellipsoidal, 12–18 x 8–10 μ , with thick epispore.

This species is another of the group which in various herbaria is often more or less indiscriminately determined as *P. rubiginosa*, *P. Mariana*, or even *P. nigrocincta*, usually without much critical attention to microscopic details.

Guanacaste: near Tilarán, both Atlantic and Pacific slopes, 500–690 m., Standley & J. Valerio 44310, Dodge & Thomas 6564, 6565.

PANNARIA radiata (Vainio) Dodge, comb. nov.

Pannaria Mariana f. *radiata* Vainio, Ann. Acad. Sci. Fenn. A67: 101–102. 1915, excl. syn.

Type: Antilles, Guadeloupe, *P. Duss.*

Hypothallus brownish black, extending about 1.5 mm. beyond the margin of the thallus, thick; thallus mineral gray with ends of lobes pale smoke gray, dichotomously (rarely trichotomously) divided, laciniae 1 cm. or more long, about 1 mm. broad, tips rounded, reflexed, wholly discrete in outer centimeter, thallus about 90 μ thick, upper cortex of large thin-walled pseudoparenchyma 20–30 μ thick, algal zone of *Nostoc* colonies ellipsoidal, about 40 μ in long diameter, medulla about 20 μ thick of loosely woven hyphae; rhizinae of conglutinate black thick-walled hyphae very closely woven at the lower side of the medulla and performing the function of a lower cortex. Apothecia mostly about 1 mm. in diameter, occasionally up to 2 mm., peltate, margin crenate, of medium prominence, disc rufous; amphithecium 160 μ thick, cortex about 60 μ thick, pseudoparenchymatous, *Nostoc* colonies smaller than in the thallus, separated by strands of pseudoparenchyma; parathecium pseudoparenchymatous, 60–80 μ thick, filamentous, of large very thick-walled hyphae appearing pseudoparenchymatous; hypothecium 15–20 μ thick,

of periclinal, thin-walled, slender hyphae; thecium 120–130 μ tall; paraphyses slender, filiform, septate, without clavate tips; asci 10–12 μ thick, 8-spored; ascospores irregularly distichous, ellipsoidal, 15–16 x 7–8 μ , with a very thick episporium.

This species shows little relationship to *P. Mariana* Fr. of the Old World, a species to which it has been referred. It seems closest to *P. Vainii* but differs in microscopic details and habit.

Limón: Hamburg, Standley & J. Valerio 48763; R. Squirres, 70–200 m., Dodge, Catt & Thomas 5596.

MALMELLA Dodge

Malmella Dodge, gen. nov.

Type species: *Erioderma physcioides* Vainio.

Thallus squamosus aut microfoliosus, rhizinis nigris bene evolutus, tomentum superficiei superioris parce evolutum tenue, hyphis implexis sed non conglutinatis ut in *Coccocarpia*; cortex superior pseudoparenchymaticus, algae nostocaceae; medulla hyphis laxae implexis, cortex inferior tenuis hyphis nigris conglutinatis aut nullus. Apothecia lecanorina, sessilia, sparsa; amphithecium adest; parathecium non pseudoparenchymaticum; paraphyses filiformes; asci clavati; ascosporae octonae, ellipsoideae, episporio crasso.

Thallus squamose or small foliose, with a well-developed hypothallus of black rhizinae; tomentum of the upper surface less well developed than in *Erioderma*, of slender hyphae loosely woven, not conglutinate as in *Coccocarpia*; upper cortex pseudoparenchymatous, algae *Nostoc*?, medulla of loosely tangled hyphae, lower cortex of black hyphae as in *Coccocarpia* or wholly absent. Apothecia lecanorine, sessile, scattered over the upper surface, not marginal as in *Erioderma*; amphithecium present; parathecium of slender hyphae, not pseudoparenchymatous; paraphyses filiform; asci clavate, 8-spored; ascospores ellipsoidal, with a thick episporium.

This genus seems intermediate between *Pannaria*, *Erioderma*, and *Coccocarpia*, and collections have been previously referred to each of these genera. In structure of the thallus it seems intermediate between *Pannaria* and *Erioderma*, while in superficial appearance it suggests the more lacinate species of *Coccocarpia*.

KEY TO THE TROPICAL AMERICAN SPECIES OF MALMELLA

Thallus becoming densely isidiose.

Thallus olivaceous with isidia becoming pruinose and subsorediate, then appearing grayish.....*M. Randii*

Thallus white, more lacinate.....*M. albida*

Thallus not isidiose, medulla not well differentiated from algal zone.

Thallus white, 120 μ thick, thecium 140–160 μ tall.....*M. Santamariae*

Thallus olive buff or darker.

Thallus olive buff, 120 μ thick, thecium 100–120 μ tall.....*M. physcioides*

Thallus dark olive with white pruina about margins, 200 μ thick, thecium 80–90 μ tall.....*M. caesiocinerea*

MALMELLA *Randii* Dodge, n. sp.

Type: Maine, Mt. Desert Island, *E. L. Rand.*

Hypothallus rhizinis viridi-nigricantibus; thallus olivaceus, lobis subdichotomis aut irregularibus, 1.0–1.3 mm. latis, marginibus crispatis elevatisque, verrucosis et etiam isidioideis, glaber in lobis marginalibus, centro isidiosissimus, apicibus isidiorum pruinosis et subsorediosis; thallus 140–160 μ crassitudine, tomentum 12 μ crassitudine hyphis laxae implexis, tenuibus, subdilatantibus; zona nostocacea [vel scytonematica] 100 μ crassitudine, filamentis dense convolutis, in coloniis ellipsoideis, cellulis sphericis vel angularibus; medulla hyphis laxae implexis 2–3 μ diametro, aut plus minusve hyphis subparallelis ut in *Coccocarpia pellita*, frequenter ad margines; cortex inferior hyphis conglutinatis nigris tenuis.

Hypothallus of well-developed greenish black rhizinae extending about 0.5 mm. beyond the thallus; thallus ecru olive to buffy olive, main lobes subdichotomous or wholly irregular, 1.0–1.3 mm. broad, margin crisped and elevated, becoming verrucose and finally isidioid, surface appearing like surface of blotting paper under microscope, smooth on marginal lobes, becoming densely isidiose toward the center, the tips of the isidia soon becoming pruinose and subsorediate, giving a puritan gray appearance to the plant; thallus about 140–160 μ thick, the tomentum 12 μ thick of loosely appressed, somewhat tangled, slender hyphae which more or less disintegrate; the upper cortex 20 μ thick, of about 2 layers of cells from the palisade; algal zone about 100 μ thick, of closely coiled filaments, forming ellipsoidal colonies, cells spherical to angular from mutual pressure, *Nostoc* or perhaps *Scytonema*; medulla of loosely woven hyphae 2–3 μ

in diameter, in places more or less parallel as in *Coccocarpia pellita*, especially at the margin of the thallus with about 1 row of agglutinated black thick-walled hyphae functioning as a lower cortex, giving off rhizinae either as single hyphae or as small fascicles of hyphae; sterile.

This species has not been seen fertile and its systematic position is uncertain. It has somewhat the appearance of an isidiose *Malmella physcioides* but differs from the latter in a less well-developed tomentum, a thinner upper cortex, and a thicker algal zone. It differs much more from *Coccocarpia cronia* in the loosely tangled tomentum layer which is present in *Coccocarpia* but closely appressed and formed of longitudinal hyphae, in the loosely tangled medulla (in *Coccocarpia* almost pseudoparenchymatous of periclinial hyphae), and the much less developed lower cortex.

MALMELLA albida Dodge, sp. nov.

Type: Costa Rica, Limón, R. Siquirres, 70–200 m., Dodge, Catt & Thomas 8060.

Hypothallus crassus, niger, bene evolutus; thallus albidus, cinerascens, laciniatus, di-vel trichotomus aut irregularis, laciniis linearibus, 0.2–0.5 mm. latis, et superficiei marginibusque dense isidiosus, coralloideis, inferne niger, rhizinis nigricantibus; thallus 80–100 μ crassitudine, cortex superior hyphis periclinalibus 5 μ et cellulis pseudoparenchymatibus 20 μ metiens, zona nostocacea (*scytonematica*?) 60 μ crassitudine, filamentis contortis, cellulis sphericis, 4–5 μ diametro; medulla 40–45 μ crassitudine, hyphis laxis implexis; cortex inferior 8–12 μ crassitudine, hyphis nigris pachydermatibus conglutinis compactus. Sterilis.

Hypothallus thick, black, well developed; thallus chalk-white, becoming ashy from isidia, lacinate, di- or trichotomous or wholly irregular, laciniae linear, 0.2–0.5 mm. broad, upper surface and margins densely isidiose, coralloid, below black with black rhizinae; thallus 80–100 μ thick, upper cortex about 25 μ thick, the outer 5 μ of periclinial hyphae, below which are about two layers of pseudoparenchymatous cells; the algal layer of *Nostoc* (*Scytonema* ?) about 60 μ thick, of contorted filaments of spherical cells 4–5 μ in diameter; medulla 40–45 μ thick, of loosely tangled hyphae; lower cortex 8–12 μ thick, of thick-walled,

black, conglomerate hyphae; sterile. Known only from a single small collection in Costa Rica.

Limón: R. Siquirres, 70–200 m., *Dodge, Catt & Thomas 8060*.

MALMELLA *Santamariae* Dodge, n. sp.

Type: Costa Rica, Guanacaste, H. Santamaría, 640–680 m., *Dodge & Thomas 8049*.

Hypothallus nullus sed rhizinae coeruleo-nigricantes, dense implexi, ei simulantes; thallus albidus, minute tomentosus, palmatim lobatus, lobis oblongis, 0.5–1 mm. latitudine, 120 μ crassitudine, cortice filamentosa, 15–20 μ crassitudine hyphis pachydermaticis periclinalibus; strato nostocaceo 40 μ crassitudine in medulla gradatim transeunte, rhizinis nigris pachydermaticis 4–5 μ diametro metientibus. Apothecia 0.5–0.75 mm. diametro marginibus crassissimis crenulatis inflexis, disco nigro; amphithecium inferne 140 μ crassitudine superne ad 100 μ attenuatum, cortice 40 μ crassitudine pseudoparenchymatico; parathecium 20–30 μ crassitudine, hyphis tenuibus periclinalibus dense implexis; thecium 140–160 μ altitudine; paraphyses tenues, filiformes, apicibus in gelatina dilabentibus; asci clavati, 12 μ diametro; ascospores distichae, octonae, 10–11 x 7–8 μ , ellipsoideae, episporiis crassis.

Hypothallus of densely tangled bluish black rhizinae; thallus white, minutely tomentose, palmately lobed, lobes oblong, 0.5–1.0 mm. broad, 120 μ thick; cortex filamentous, 15–20 μ thick, of thick-walled hyphae, algal layer of *Nostoc* gradually merging into the medulla; rhizinae thick-walled, black, 4–5 μ in diameter. Apothecia 0.5–0.75 mm. in diameter, with very thick inrolled margins and blackening disc; amphithecium 140 μ thick below, thinning to 100 μ at the margin, cortex 40 μ thick, pseudoparenchymatous; parathecium 20–30 μ thick, of densely appressed periclinal hyphae not clearly differentiated from the hypothecium; thecium 140–160 μ tall; paraphyses very slender, filiform, degenerating into the dark brown epithelial gel; asci clavate, 12 μ in diameter, 8-spored; ascospores distichous, ellipsoidal, with thick episore, 10–11 x 7–8 μ .

While eventually this species may be found to have a much wider distribution, it seems fitting that the excellent H. Santamaría, with one of the richest lichen floras known to me, should be

commemorated in botanical literature. The hacienda in turn preserves the name of the national hero of Costa Rica not far from the scene of his famous exploits.

Guanacaste: H. Santamaría, 640–680 m., *Dodge & Thomas 8049*.

MALMELLA physcioides (Vainio) Dodge, n. comb.

Erioderma physcioides Vainio, Jour. Bot. Brit. & For. **34**: 70. 1896.

Type: West Indies, St. Vincent, Boxwood, *W. R. Elliott 252*.

Hypothallus sparingly developed, strigose-pannose, greenish black; thallus deep olive buff, radiately subpinnatifid, ultimate lobes 1–1.5 mm. broad, short and convex, surface toward the margin slightly spongy, very minutely verrucose, about 120 μ thick, upper cortex about 40 μ thick, of large thin-walled pseudo-parenchyma, the rest of loosely woven hyphae with very small, separate colonies of *Nostoc*, the lower 10 μ with more densely woven, more or less parallel hyphae. Apothecia circular to quite irregular by mutual pressure, crowded, about 1 mm. in diameter, margin concolorous with the thallus, crenulate, disc chestnut; amphithecium about 200 μ thick, the outer 60 μ of tomentum consisting of slender, thin-walled hyphae more or less perpendicular to the surface and somewhat tangled. Within this is the true cortex about 30 μ thick of large-celled pseudo-parenchyma, thinning out to a single layer above, and the algal layer of slender periclinal thin-walled hyphae and colonies of *Nostoc* about 100 μ thick below and about 80 μ above; parathecium about 40 μ thick, of densely woven periclinal hyphae, staining very lightly and reaching the margin above; hypothecium deeply staining, 15–20 μ thick, of densely woven hyphae; thecium 100–120 μ tall; paraphyses filiform, 2 μ in diameter, frequently septate, disintegrating into the brownish epithecial gel; asci clavate, 6–8 μ in diameter, 8-spored; ascospores broadly ellipsoidal, 10–12 x 6–8 μ , with a gelified wall, minutely roughened within.

Previously reported only from the type locality. I have previously distributed duplicate material of this species under the name *P. imbricatula* Müll. Arg., which was originally briefly described from southern Brasil. Only a careful study of both types can settle its identity and relationships.

Alajuela: Fraijanes, 1500–1700 m., *Standley & J. Valerio 47651*; S. Isidro de Alajuela, 980–1300 m., *Dodge, J. Valerio & Thomas 4883*.

Guanacaste: H. Santamaría, 640–780 m., *Dodge & Thomas 8034, 8035*.

MALMELLA caesiocinerea (Vainio) Dodge, n. comb.

Pannaria rubiginosa f. *cinerascens* Vainio, Jour. Bot. Brit. & For. 34: 70 [10]. 1896, non Nyl.

Pannaria rubiginosa f. *caesiocinerea* Vainio, Acta Soc. Sci. Fenn. A67: 102-103. 1915.

Type: not stated although several specimens mentioned. *P. rubiginosa* f. *cinerascens* Vain. based on Antilles, St. Vincent, Mt. St. Andrews, 320 m., *Elliott 15*. The following description is based on Costa Rican material.

Rhizinae bluish black, highly developed and tangled; thallus buffy brown in the center, lobes dark olive with a white pruina about the margins, tomentose, lobes rounded, 1-4 mm. broad, sinuate, incised, the lobules oblong, about 0.5 mm. broad, convex, margins thick, inflexed below, 200 μ thick, the upper cortex a palisade of thick-walled hyphae about 20 μ thick, homoeomerous, with coiled filaments of *Nostoc* distributed throughout a very loosely tangled layer of hyphae, fraying out below without lower cortex. Apothecia up to about 0.5 mm. in diameter, margin very thick and inrolled, white, crenulate, disc black; amphithecium thick, continuous with the thallus, about 140 μ thick, with cortex about 60 μ thick below and with algae much more abundant and closely tangled than in the thallus; parathecium thin, filamentous, 20 μ thick, not differentiated from the hypothecium; thecium 80-90 μ tall; paraphyses filiform, septate, ending in the hypothecial gel which is deep brown and deeply staining; asci clavate, about 20 μ in diameter, 8-spored; ascospores distichous, ellipsoidal, 11-12 x 6-7 μ , with a gelified epispore about 2 μ thick, sometimes appearing 2-celled or even 4-celled with 2 transverse septa and 1 longitudinal septum in the middle, probably due to oil globules or other highly refractive substances, as other spores in the same ascus seem to be definitely unicellular.

This species suggests a close relationship with *Lepidocollema* but the cortex is much better developed and the apothecium is lecanorine.

Guanacaste: H. Santamaría, 640-680 m., *Dodge & Thomas 8033*.

PARMELIELLA Müll. Arg.

PARMELIELLA Müll. Arg., Mem. Soc. Phys. Hist. Nat. Genève 16: 376. 1862.

Type species: *P. triptophylla* (Ach.) Müll. Arg. [*P. corallinoides* (Hoffm.) Zahlbr.].

Thallus squamose, becoming elongate and subfoliose at the margins with a well-developed dark hypothallus, algae *Nostoc*; upper cortex of thick-walled pseudoparenchyma; medulla loosely woven; lower cortex an appressed layer of rhizinae. Apothecia superficial; amphithecium absent; parathecium pseudoparenchymatous; asci 8-spored; spores hyaline, unicellular, elongate-ellipsoidal with thin walls; spermatia short, straight.

This genus seems world-wide in its distribution, perhaps predominantly of the southern hemisphere but widespread in the North Temperate zone and in the tropics, preferring the higher elevations. Only *P. pannosa* has yet been found in Costa Rica. The other species have been incompletely described but have characters which should make them recognizable if found.

KEY TO THE TROPICAL AMERICAN SPECIES OF PARMELIELLA

Hypothallus indistinct, thallus glauco-cinereous or pale, squamules confluent, crenate, granulate; spores small, $8-9 \times 4-6 \mu$; Chile. *P. microphyloides*

Hypothallus forming a black margin about the thallus.

Hypothallus very thin, blue green; spores $15-19(-21) \times 6.5-8 \mu$; surface smooth; thecium 100μ thick; Chile. *P. nigrocincta*

Hypothallus blue black, densely woven, cortex a single layer of cells; spores $11-17 \times 5-8 \mu$; thecium 110μ thick; Mexico. *P. miradorensis*

Hypothallus brownish black, densely woven and thick, cortex several layers of pseudoparenchyma; spores $12-15(-18) \times 6-8 \mu$; thecium $120-140 \mu$ thick. *P. pannosa*

Hypothallus very thick; apothecia 1-1.5 mm. in diam.; spores $16-25 \times 8-10 \mu$; Bolivia. *P. nigrocincta* var. *Weddellii*

PARMELIELLA PANNOSA (Sw.) Müll. Arg., Flora 64: 86. 1881.

Lichen pannosus Sw., Nova Gen. Sp. Pl. Prodr. 146. 1788; Fl. Ind. Occ. 3: 1888. 1806.

Type: Jamaica, O. Swartz.

Hypothallus brownish black, extending 1-2 mm. beyond the thallus; thallus tawny olive to isabelline, irregularly somewhat pinnatifidly divided in the margin, the central portion of the thallus becoming appressed microphylline and even somewhat isidioid, margins of lobes somewhat lighter in color, otherwise smooth above; thallus about 100μ thick, the upper cortex 40μ thick, of large thick-walled spherical cells forming a pseudoparenchyma, algal zone thin, about 20μ thick, of small somewhat

confluent colonies, medulla about 40 μ thick, of large thin-walled, loosely woven hyphae, the lower cortex 10–12 μ thick, of conglutinate, black, thick-walled hyphae. Apothecia abundant, about 1 mm. in diameter, round to irregular in shape, the margin lighter colored when young, appearing to be thalline but not so, darkening in age but always slightly lighter than the disc and not exceeding the epithecium in height, disc rufous; amphithecium absent; parathecium 100–120 μ thick, pseudoparenchymatous, of large thick-walled cells extending to the top of the thecium; hypothecium about 40 μ thick, of densely woven hyphae, deeply staining; thecium 120–140 μ thick; paraphyses branched above, 1.5–2 μ in diameter, with thin walls; asci clavate, about 15 μ in diameter, 8-spored; ascospores irregularly distichous, ellipsoidal, 12–15 x 6–8 μ , epispore thick.

This species seems to be the commonest one in tropical America, in our area confined largely to higher elevations than *Pannaria*, being most abundant above 650 m., but rarely found at lower elevations.

Without locality: Ørsted 8.

Limón: Waldeck, Dodge 7403.

Cartago: R. Pejivalle, 600–750 m., Dodge & Thomas 4341, 8038; Cartago, 1200–1500 m., C. Wercklé (Mus. Nac. 17218).

San José: Sta. María de Dota, 1500–1800 m., Standley & J. Valerio 43394, 44057, 43444, 43446, 43472; La Hondura, 1300–1700 m., Standley 36458b.

Heredia: Barba, El Gallito, R. Torres 150; C. Central de Zurquí, 1600–1700 m., Dodge, J. Valerio & Thomas 8039.

Alajuela: S. Ramón, La Palma, 1100 m., Brenes 54; Piedades, 900 m., Brenes 380; Alto Calera, 750–800 m., Brenes 265.

Guanacaste: H. Santamaría, 680–780 m., Dodge & Thomas 6892; H. Granadilla, 500–600 m., Dodge & Thomas 6746.

Var. *coralloidea* Dodge, var. nov.

Type: Costa Rica, Heredia, C. Zurquí, 1600–1700 m., Dodge, J. Valerio & Thomas 8061.

Thallus iteratim laciniatus sed non microphyllinus, isidiis coralloideis marginalibus rare sparsis, obscurior, 140 μ crassitudine, cortex superior 25–30 μ crassitudine, duobus seriebus cellularum, serie superiore fusca, inferiore hyalina; stratum nostocaceum ad 60 μ crassitudine, filamentis dense contextum; medulla hyphis magnis laxè implexa; cortex inferior ad 12 μ crassitudine, hyphis nigris, pachydermaticis, conglutinatis, compactus; sterilis.

Thallus repeatedly lacinate but not microphylline, isidia coralloid, mostly marginal, rarely scattered over the surface, darker, 140 μ thick, the upper cortex 25–30 μ thick, of two layers of thick-walled cells, the outer layer fuscous, the inner hyaline; the algal layer about 60 μ thick, of densely woven filaments of *Nostoc*; medulla of large loosely tangled hyphae; lower cortex about 12 μ thick of large black, thick-walled hyphae; sterile.

Heredia: C. Central de Zurquí, 1600–1700 m., Dodge, J. Valerio & Thomas 8061.

ERIODERMA Fée

ERIODERMA Fée, Essai Cryptog. Ecorc. Offic. 146. 1824.

Type species: *Erioderma polycarpum* Fée.

Thallus foliose, attached to the substrate by either marginal rhizinae or those from the under surface; tomentum highly developed, cortex pseudoparenchymatous, formed by a palisade layer, the algal zone of short chains of *Scytonema* with thin sheaths or *Nostoc*; medulla loosely woven of thin-walled hyphae; no lower cortex, the lower surface somewhat veined and in some species with a dense covering of rhizinae. Apothecia marginal or superficial, peltate, constricted at the base; amphithecium absent; parathecium well developed, of large thick-walled cells, pseudoparenchymatous, with a loosely woven medulla; asci 8-spored; spores hyaline, unicellular, ellipsoidal, occasionally fusiform or subspherical. Spermatogonia marginal, small, blackish warts; spermatophores septate; spermatia short, cylindric, straight.

KEY TO THE TROPICAL AMERICAN SPECIES OF ERIODERMA

Dense blackish fuscous tomentum below, suggesting hypothallus.

Lobes narrow, deeply sinuate divided margins.....*E. Wrightii*

Lobes broader, margin with sub-granulate caesious soredia below, and white-villose.....*E. limbatum*

Nearly nude and veined, white below, although rhizinae bluish black or white, verruculose and villose above; Brasil.....*E. verruculosum*

Sulphur yellow below with white veins and rhizoids, coarsely short-pilose above; apothecia up to 0.8 mm. in diam.; Jamaica.....*E. microcarpa*

Bluish white with fleshy white veins and rhizoids, hairs tufted above, giving an irpiciform appearance when dry; apothecia 3–4 mm. in diam.; Brasil.....*E. pulchrum*

White below; thallus isidioid; apothecial margin isidioid, ashy virescent above; Brasil.....*E. Leylandi*

ERIODERMA WRIGHTII Tuck., Amer. Jour. Arts & Sci. II, 25: 423. 1858.

Type: Cuba, top of Loma del Gato, *C. Wright*.

Hypothallus none, but dense brownish-black rhizinae clothe the under surface to within 3 mm. of the margin which is arachnoid-tomentose, white; thallus deep olive buff to citrine drab, sinuate-lobed, upper surface tomentose, margins with tufts of dark brown rhizinae, thallus about 120 μ thick exclusive of tomentum on upper surface and rhizinae below; cortex pseudoparenchymatous, 30–40 μ thick, of large cells, algal layer very thin, 10–15 μ thick, of densely coiled filaments of *Scytonema*; medulla very loosely woven, similar to the tomentum above; no lower cortex. Apothecia marginal with white densely pilose exciple and black disc; amphithecium absent; parathecium 200 μ thick, corticate with pseudoparenchyma about 25 μ thick below, a little less above, formed from a palisade of hyphae perpendicular to the surface, the cortex covered with tomentum as in the thallus, the rest of the parathecium of large, loosely woven hyphae similar to the medulla but somewhat more closely woven; hypothecium not well differentiated from the parathecium, rather more densely woven; thecium about 120 μ tall; paraphyses filiform, slender, branched above, ending in dense brown epithecial gel; asci clavate, 8-spored, 14–16 μ in diameter; ascospores distichous, 12–14 x 6–7 μ , ellipsoidal, with a thick epispore.

This very distinct species resembles the Peltigeraceae in habit much more than the Pannariaceae, but it has the typical unicellular spore with the thick epispore of the latter family. It seems rather rare in tropical America but it is quite abundant in the few localities where it has been found. In Costa Rica it occurs from 680 to 1100 m.

Alajuela: La Palma de S. Ramón, 1100 m., *Brenes 50*.

Guanacaste: H. Santamaría, 680–780 m., *Dodge & Thomas 6920, 6982*.

ERIODERMA limbatum (Nyl.) Dodge, n. comb.

Erioderma Wrightii var. *limbatum* Nyl., *Flora* 52: 119. 1869.

Type: Brasil, Rio de Janeiro, Serra dos Orgãos, *Glaziou 2004*.

Thallus cinnamon buff to chamois, lobes rounded-sinuate, slightly excised, 5 mm. broad, margins crenate, thick, upper surface only slightly tomentose, lower surface with margins caesious-sorediate, white; rhizinae greenish black, very dense and thick; thallus about 300 μ thick, upper tomentum not highly

developed; cortex 25–30 μ thick, pseudoparenchymatous from the disintegration of a palisade; algal layer about 60 μ thick, of irregularly tangled filaments of irregular somewhat angular cells about 8 μ in diameter (*Scytonema* ?); medulla about 60 μ thick next the cortex, of rather densely tangled hyphae, gradually becoming looser to form another indefinite layer 120 μ thick, of very large and very loosely tangled hyphae 10–12 μ in diameter, with black hyphae of about the same size forming a more dense mat which serves as a lower cortex. Apothecia 3 mm. in diameter, stipitate, stipe 1–2 mm. tall, margin thin, erect or incurved, densely tomentose without, the hairs tangled, giving a granular appearance, disc chestnut, soon blackening; no amphithecium; parathecium highly developed, cortex a palisade of thick-walled infrequently septate hyphae proliferating to form the tomentum and medulla, 200 μ or more thick below, thinning out at the edge of the thecium so that only the cortex about 100 μ thick surrounds the upper portion of the thecium at the margin; hypothecium not differentiated; thecium about 90 μ tall; paraphyses slender, filiform, apex not enlarged; asci cylindrical, about 8 μ in diameter, 8-spored; ascospores monostichous, at least when found, thick-walled, hyaline, ellipsoidal, 10–12 x 5–6 μ .

This species, from its habit and color, might easily be mistaken for *Sticta Weigelii* or *S. rufa* except for a somewhat duller surface, but is distinguishable on the color and density of the rhizinae and the lack of cyphellae. Known from Costa Rica from a single collection with scant data by *Brenes* . . . *a*, probably from the region of S. Ramón in Alajuela Province.

COCCOCARPIA Pers. ap. Gaudich.

COCCOCARPIA Pers. ap. Gaudich. in Freycinet, Voy. Uranie, Bot. 206. 1826.

Type species: *Coccocarpia molybdaea* Pers. ap. Gaudich.

Thallus squamose to foliose, with dark or light-colored rhizinae, corticate on both surfaces, upper surface pseudoparenchymatous from thin-walled large hyphae parallel to the surface, without tomentum; algal layer of coiled chains of *Scytonema* in thin sheaths; medulla of thin-walled somewhat conglutinate hyphae not sharply differentiated from the lower cortex, of more or less

septate hyphae running parallel to the surface. Apothecia superficial, sessile or somewhat constricted below; amphithecium absent; parathecium corticate with large-celled pseudoparenchyma, within, of large septate periclinal hyphae, medulla lacking; hypothecium either light or dark; asci 8-spored; ascospores hyaline, unicellular, spherical to ellipsoidal-fusiform, thin-walled. Spermatogonia in warts on the thallus, spermatophores frequently septate; spermatia straight, elongate-cylindric.

This widespread tropical genus has two very widespread species or species groups and a number of rare and seemingly localized species scattered over the tropical regions.

KEY TO THE TROPICAL AMERICAN SPECIES OF COCCOCARPIA

- Under side reticulate, black-fibrillose; lobes obtuse, ciliate, margin of apothecia crenulate, disc yellow.....*C. portoricensis*
- Under side densely black-tomentose, forming a hypothallus.
 - Lobes bipinnately divided, linear, ciliate, aeruginous-green.....*C. subtilis*
 - Lobes cuneate to flabelliform, bluish to lead color.
 - Thallus isidiose or microphylline in the center.....*C. cronia*
 - Thallus not reddish ferruginous within.
 - Isidia concolorous, laciniae cuneate, 1.5–10 mm. broad.
 - Laciniae 5–10 mm. broad, isidia applanate to microphylline....
.....*v. prolificans*
 - Laciniae 1.5–5 mm. broad, isidia terete; apothecia yellow or rufo-fuscous, exciple white-ciliate.....*v. isidiophylla*
 - Isidia usually darker at the tips and blackening, laciniae narrower and sublinear.
 - Laciniae 1–1.5 mm. broad; hypothallus little developed; apothecia fuscous, blackening, exciple white-ciliate; Brasil...*v. camporum*
 - Laciniae 0.5–3.0 mm. broad, narrow granulate to lobulate in the center; apothecia black; hypothallus well developed....*v. granulosa*
 - Thallus reddish ferruginous within; Cuba.....*v. erythrocardia*
 - Thallus not isidiose in center.....*C. pellita*
 - Laciniae cuneate or broad-spathulate.
 - Hypothallus very highly developed; apothecia yellow to tawny when young.....*v. pannosa*
 - Hypothallus present but much less well developed.
 - Apothecia black from the first, laciniae broad.....*v. parmelioides*
 - Apothecia yellow, rufous, or fuscous.
 - Thallus very thin, lobes small, approaching microphylline states of *C. cronia v. prolificans*; apothecia finally darkening.....*v. lividorufa*
 - Thallus thicker, lobes broad, 4–8 mm.; apothecia not darkening, reddish.....*v. pyrrhohocarpa*
 - Laciniae sublinear, up to 4 mm. broad, short, rounded.
 - Apothecia black; Jamaica.....*v. genuina*
 - Apothecia fuscous, ciliate.....*v. strig^{oso}*

Under side of thallus white with black-fibrillose margins, laciniae lacerate-imbricate. *C. fibrillosa*

Under side of thallus white, rhizinae white.

Thallus isidiose.

Laciniae very narrow, 0.1–0.2 mm. broad, adnate. *C. dominguensis*

Laciniae broad and flabelliform, up to 10 mm. broad. *C. albida*

Thallus not isidiose.

Laciniae 150–200 μ broad, loosely adnate, bluish; rhizinae penicilloid, projecting beyond margin, dichotomous. *C. tenuissima*

Laciniae 250 μ broad, tips ascending, bluish; long white rhizinae, palmate with lacinulae pinnatifid; apothecia carneous, rigidly white-ciliate. *C. elegans*

Laciniae broader.

Thallus greenish blue, rhizinae rigid, white; flattened apothecia cerine-flavous. *C. epiphylla*

Thallus lead-color or slightly bluish, crenate-squamulose, subimbricate, pterygoid; apothecia testaceous, white, ciliate. *C. asterella*

COCCOCARPIA PELLITA (Ach.) Müll. Arg., Flora 65: 320. 1882.

Parmelia pellita Ach., Lichenog. Univ. 468. 1810, Sw., Lich. Amer. 7, pl. 6. 1811.

Type: West Indies, *O. Swartz*.

Laciniae of thallus rather narrow, about 4 mm. broad, pinnatifidly incised, either discrete or approximate, smooth above; hypothallus well developed and extending beyond the thallus. Apothecia deep fuscous.

This species seems widely distributed and very variable in the tropics. Only a monographic study by one who has access to the types of all the proposed varieties as well as considerable experience in the field in the principal floristic areas of the tropics can finally decide the validity of the proposed varieties and forms and provide adequate descriptions so that others may recognize them. Nylander, Müller Argau, Hue, Vainio, and Malme have each attempted more or less elaborate revisions but none seems wholly satisfactory. While probably artificial the separation of *C. cronia* for all the isidiose varieties of this species is relatively easy to apply, and has been followed here.

Var. *PARMELIOIDES* (Hook. ap. Kunth) Müll. Arg., Flora 65: 320. 1882.

Lecidea parmelioides Hook. ap. Kunth, Syn. Pl. Aequinoct. Orb. Nov. 1: 15. 1822.

Type: Colombia, Cumana, Bordones, and Nueva Barcelona, *Humboldt & Bonpland*.

Thallus light olive gray, surface smooth, lobes cuneate, about 4 mm. wide, sometimes once-cleft, closely appressed to the substrate, held by a few dark brown to black rhizinae composed of fascicles of hyphae, about 200 μ thick; upper cortex about 25 μ thick, the outer 5 μ formed from the disintegration of a very thin layer of periclinal hyphae, the rest pseudoparenchymatous from the shifting of cells in a palisade layer, cells 10–12 μ in diameter, rather thick-walled; algal layer a palisade of hyphae and filaments of *Scytonema* about 100–120 μ thick; medulla about 40 μ thick, of large septate periclinal hyphae 5–8 μ in diameter; lower cortex of dark, periclinal conglomerate thick-walled hyphae 3–4 μ in diameter. Apothecia immarginate, appressed and more or less adnate, 2 mm. or more in diameter, disc black; no amphithecium; parathecium of periclinal thick-walled hyphae, giving a pseudoparenchymatous appearance, 100–120 μ thick, thinning out to about 20 μ at the edge; hypothecium not differentiated from the parathecium; thecium about 160 μ tall; paraphyses 2–3 μ in diameter, frequently septate, clavate tips black, about 4 μ in diameter; asci cylindric to somewhat clavate, 8-spored, about 60 x 8–12 μ ; ascospores monostichous at first, gradually becoming distichous, ellipsoidal with acute ends, very thick-walled, unicellular, often with some deeply staining material in the middle with a slight thickening of the cell wall at that point, giving the appearance of a two-celled polarilocular spore with a wide isthmus, occasionally two other constrictions near the tip slightly suggesting a 4-celled condition, 11–12(–16) x 6–7 μ .

This variety seems widespread in the lower elevations although in absence of apothecia it is practically indistinguishable from var. *pyrrhichocarpa*. In Costa Rica var. *parmelioides* occurs in suitable habitats up to about 800 m., while var. *pyrrhichocarpa* occurs from 700 to 1340 m., but seen from Brasil up to 2000 m. in the state of São Paulo.

Limón: Waldeck, 40 m., Dodge 7402.

Guanacaste: H. Santamaría, 680–780 m., Dodge & Thomas 4709; C. San José de Libano, 500–960 m., Dodge, Hanckel & Thomas 6684; R. San José, 460–480 m., Dodge & Thomas 6581.

Puntarenas: Osa, Puerto Jiménez, Brenes 825a; R. Sándalo, Dodge 7742.

Var. PYRRHICHOCARPA Hue, Bull. Soc. Bot. France 48: lx. 1901 [1902].

Var. *smaragdina* Müll. Arg., Flora **65**: 320. 1882, excl. syn. quoad specimina americana; Vainio, Étude Lich. Brésil **1**: 210. 1890; Malme, Ark. f. Bot. **20**³: 19. 1924.

Type: Brasil, São Paulo, near São Paulo, *Azevedo Sampaio*.

Thallus between yellowish glaucous and light mineral gray, lobing of thallus similar to var. *parmelioides* but much more irregular and lobes rather smaller, smooth above, 150–160 μ thick, upper portion of cortex 4–6 μ thick, of longitudinal hyphae soon disintegrating and disappearing, leaving a palisade 25–30 μ thick, which in turn becomes a somewhat irregular large-celled pseudoparenchyma; the algal layer 40–50 μ thick, of loosely coiled and disintegrating filaments, perhaps *Scytonema*, but the cells rounding up and suggesting *Nostoc*, about 8 μ in diameter, the medulla 50 μ thick, of large septate periclinial hyphae, somewhat less compact than in var. *parmelioides*, the lower cortex about 25 μ thick, of black somewhat smaller congrutinate hyphae; rhizinae much more abundant, smaller congrutinate fascicles of hyphae similar to those of the lower cortex. Apothecia irregular, 3–3.5 mm. in diameter, carnelian red to vinaceous rufous, only slightly darkening, never dark brown or black, immarginate; amphithecium absent; parathecium adnate to the upper cortex, about 100 μ thick, of large periclinial hyphae appearing almost pseudoparenchymatous at times; thecium 60 μ tall; paraphyses 2–3 μ in diameter, filiform, apex not enlarged; asci clavate, about 12 μ in diameter; ascospores 10–14 x 4–5 μ .

This variety is occasional at the medium elevations of the temperate zone in Costa Rica, ranging from 700 to 1400 m. It should not be confused with *C. smaragdina* Pers. or *C. molybdaea* Pers., both from the Old World tropics.

Cartago: R. Birris near Santiago, 920–1340 m., *Dodge 4708, 8050*; Cartago, *C. Wercklé* (Mus. Nac. 172186 p. min. p.).

Alajuela: Santiago de S. Ramón, 1000 m., *Brenes 238*.

Guanacaste: H. Santamaría, 680–780 m., *Dodge & Thomas 6813*.

Var. STRIGOSA Müll. Arg., Flora **65**: 326. 1882.

Coccocarpia molybdaea v. *cronia* Nyl., Acta Soc. Sci. Fenn. **7**: 441. 1863, non Tuck.

Type: Colombia, Cune, 1200 m., *Lindig 2663 p. p.*

Thallus between pale olive buff and yellowish glaucous, lobes cuneate but narrower than in v. *parmelioides*, slightly incised,

smooth and shining above, thallus about 100 μ thick, outermost layer of hyphae about 4 μ thick, soon disintegrating, upper cortex pseudoparenchymatous, 10–12 μ thick, of about two layers of pseudoparenchymatous cells not part of a palisade, algal layer 32–40 μ thick, of curved hyphae in a disintegrating palisade (intermediate between v. *parmelioides* and v. *pyrrhichocarpa*), medulla 25–30 μ thick, of large periclinal hyphae, lower cortex 12–15 μ thick, of large black periclinal hyphae, closely agglutinated rhizinae abundant but hyphae less fasciculate. Apothecia about 2 mm. broad, ochraceous tawny at first, becoming Prout's brown or darker, immarginate; no amphithecium; parathecium about 100 μ thick, of large periclinal hyphae, at the margins many hyphae projecting beyond the general level as stiff hairs; hypothecium not differentiated and not deeply staining; thecium about 40 μ tall; paraphyses filiform with acuminate tips which extend 1–2 μ above the epithecial gel; asci clavate, 30 x 8 μ , with 8 spores; ascospores fusiform-ellipsoidal, 8 x 4 μ , thick-walled, probably still immature.

In the only collection from Costa Rica the thallus may not be quite mature, as no mature ascospores were found, hence the measurements may be a little small. Reported elsewhere only from Colombia.

Cartago: R. Birris, 920–1100 m., *Dodge 8051*.

COCCOCARPIA CRONIA (Tuck.) Vainio, *Ann. Acad. Sci. Fenn. A67*: 103. 1915.

Parmelia cronia Tuck., *Proc. Amer. Acad. Arts & Sci.* 1: 228. 1848; *Syn. Lich. New England*, 36. 1848.

Coccocarpia molybdaea v. *cronia* Nyl., *Syn. Meth. Lich.* 2: 41. 1863.

Coccocarpia pellita v. *cronia* Müll. Arg., *Flora* 65: 321. 1882.

Coccocarpia parmelioides v. *cronia* Hue, *Bull. Soc. Bot. France* 48: lx. 1901 [1902].

Type: United States, Massachusetts, Lynn Hills, and West Cambridge, on mossy rocks, *Tuckerman*.

Thallus mineral gray or darker, lobes rounded or short, broad-linear, more or less appressed, growing over mosses, about 130–140 μ thick; upper cortex 15–20 μ thick of large thin-walled hyphae often appearing pseudoparenchymatous; algal zone

30–40 μ thick, with loosely woven hyphae in which are imbedded solid little groups 15–20 μ in diameter of algal cells of closely coiled *Scytonema*; medulla 30–40 μ thick, partly of close periclinal hyphae, partly more loosely woven, the lower cortex of two layers of black thick-walled hyphae giving rise to rhizinae, sterile; isidia terete, concolorous, or somewhat darkened at the tips. Tuckerman noted on a specimen from Alabama, “spores 9–12 x 3–5 μ , 2-celled?”

Var. *LIVIDORUFA* (Mey. & Fw.) Zahlbr., Cat. Lich. Univ. 3: 287. 1925.

Parmelia lividorufa Mey. & Fw., Nova Acta Acad. Leopold. Carolin. 19: Suppl. 222, pl. 4, f. 2. 1843.

Coccocarpia molybdaea var. *tenuior* Nyl., ap. Krmphbr., Flora 59: 76. 1876 (nom. nud.).

Coccocarpia pellita var. *tenuior* Müll. Arg., Flora 65: 321. 1882.

Type: Brasil, Rio de Janeiro, *Meyen* (Bot. Mus. Berlin), type of var. *tenuior*; same locality, *Glaziou 2026* (Univ. Genève).

Thallus mineral gray, lobes small, mostly about 1 mm. broad, quite irregular, smooth, about 100 μ thick, structure as in the previous variety. Apothecia immarginate, irregular, convex, disc snuff brown to bister; amphithecium absent; parathecium 130–140 μ thick; hypothecium not differentiated; thecium 80–85 μ tall; paraphyses filiform, ending in the epithecial gel; asci 8-spored, clavate to cylindrical, 12 μ in diameter, ascospores 11–12 x 5–6 μ , ellipsoidal, thick-walled, distichous.

In this variety the whole thallus approaches a microphylline squamose state. Evidently a lowland variety seen also from British Honduras and Nicaragua.

Limón: R. Siquirres, 70–200 m., *Dodge, Catt & Thomas 8058*.

Alajuela: La Palma de S. Ramón, 1100 m., *Brenes 43*.

Guanacaste: Tilarán, 650–690 m., *Dodge & Thomas 6557*.

Var. *ISIDIOPHYLLA* (Müll. Arg.) Dodge, comb. nov.

Coccocarpia pellita v. *isidiophylla* Müll. Arg., Flora 65: 321. 1882.

Coccocarpia pellita v. *cronia* Vainio, Étude Lich. Brésil 1: 209. 1890, et auct. recentior., non Tuck.

Coccocarpia cronia v. *primaria* Vainio, Ann. Acad. Sci. Fenn. A67: 103. 1915.

Type: Brasil, Rio de Janeiro, *Glaziou 2025*.

Thallus mineral gray or darker, laciniate, flabelliform or cuneate with rounded margin about 4 mm. broad, sometimes somewhat incised along the margin, upper surface isidiose with either simple or slightly branched isidia which are confined to the central portion of the thallus and to a lesser extent of the lobes; upper cortex of large thin-walled hyphae perpendicular to the margins of the lobes, up to about 20 μ thick, closely septate; algal zone 60 μ thick of filaments of *Scytonema* about 12 μ thick with cells about 8 μ in diameter, in the lower portion the algae less crowded, leaving some air spaces, medulla not differentiated from the algal zone; lower cortex 30 μ thick, of conglomerate, black, thick-walled hyphae, giving rise to scattered rhizinae as well as penicillate fascicles of hyphae. Apothecia yellowish-rufous, becoming fuscous, somewhat lobulate, immarginate, adnate; parathecium 55–60 μ in the center, thinning out at the margin, pseudoparenchymatous, of large somewhat periclinal hyphae; hypothecium not differentiated, about 60 μ thick; paraphyses 2–3 μ in diameter, filiform, with swollen tips in the very dark epithelial gel; asci clavate, 8-spored, 8–10 μ in diameter; ascospores distichous, fusiform, immature.

This species is close to *C. pellita* and perhaps should be considered a variety of that species. It has approximately the same distribution, reaching from sea level to about 1700 m. in Costa Rica, 2700 m. in Perú.

Cartago: Aguacaliente, 1240–1460 m., *Dodge & Thomas 7087*.

Heredia: C. Central de Zurquí, 1600–1700 m., *Dodge, J. Valerio & Thomas 6087*; C. de las Caricias, 2000–2400 m., *Standley & J. Valerio 55282*.

Alajuela: La Palma de S. Ramón, 1100 m., *Brenes* (fertile).

Puntarenas: Osa, between R. Sándalo and R. Tigre, 1–2 m., *Dodge 8057*.

Var. *prolificans* (Malme) Dodge, n. comb.

Coccocarpia pellita var. *prolificans* Malme, Ark. f. Bot. **20**: 19. 1924.

Type: Brasil, Rio de Janeiro, *Regnell 65*.

Thallus mineral gray or darker, lobes flabelliform, somewhat zonate, 5–10 mm. wide, margin rounded, more or less lobulate along the incised portions between lobes, upper surface lobulate and more or less microphylline, lobules concolorous, about 70 μ thick, upper cortex about 16 μ thick, of large thin-walled longitudinal hyphae; algal zone about 30 μ thick, of a loose palisade

of *Scytonema* filaments, medulla about 20 μ thick, of large thin-walled periclinal hyphae with some air spaces; lower cortex about 15 μ thick, of thick-walled black hyphae, giving off fascicles of rhizinal hyphae. Sterile.

This variety is rather common at elevations from 700 to 1400 m. in Costa Rica.

Cartago: R. Birris, 1220–1340 m., *Dodge & Thomas 4710*.

Alajuela: La Palma de S. Ramón, 1250 m., *Brenes 38a*; Piedades de S. Ramón, 900 m., *Brenes 385*.

Guanacaste: H. Santamaría, 680–780 m., *Dodge & Thomas 6987, 6999*.

Var. **granulosa** (Müll. Arg.) Dodge, comb. nov.

Coccocarpia pellita var. *granulosa* Müll. Arg., *Flora* 65: 322. 1882.

Type: Brasil, São Paulo, Apiahy, *Puiggari 244*, and Colombia, Bogotá, 2700 m., *Lindig 2538*.

Thallus thicker, greenish-glaucous-blue or darker, lobes up to 3 mm. broad, the larger lobes more or less incised, obovoid to almost linear, soon blackish granular to almost isidiose in the center, about 140 μ thick, upper cortex a single layer of longitudinal hyphae 4–5 μ in diameter, algal zone of *Scytonema* filaments 40–50 μ thick, forming a palisade interspersed with occasional rows of fungal cells, medulla of large, septate, periclinal hyphae about 60 μ thick, the lower cortex 6–8 μ thick, of thick-walled dark hyphae, not well developed. Apothecia less adnate and somewhat isidiose; no amphithecium; parathecium 150 μ thick, pseudoparenchymatous, some of the outer layer of cells growing downward to form a ciliate to tomentose surface below; hypothecium not differentiated, thecium about 60 μ tall; paraphyses filiform, tips not enlarged, ending in a dark brown epithelial gel; asci clavate, rather immature.

This variety as here defined includes some of Malme's var. *isidiosa* and some material may have been distributed under that name. In Costa Rica this variety is widespread in the temperate regions from 100 m. to 1500 m.

Limón: R. Siquirres, 70–200 m., *Dodge, Catt & Thomas 5595*.

Cartago: Santiago, 1140–1180 m., *Dodge 4638, 8054*; C. Carpintera, 1320–1500 m., *Dodge & Thomas 4763*; Cartago, *C. Wercklé* (Mus. Nac. 17202).

San José: Turrúcares, 540–600 m., *Dodge & Thomas 8056*; R. Virilla below El Brazil, *Dodge 7777*.

Alajuela: C. Pata de Gallo a S. Rafael de S. Ramón, 1200–1250 m., *Brenes 215*; S. Pedro de S. Ramón, 700 m., *Brenes 459*.

Guanacaste: Liberia, 100 m., *Dodge & Thomas 6582*; H. Santamaría, 640–780 m., *Dodge & Thomas 6900, 7007, 8055*; Tilarán, 650–690 m., *Dodge & Thomas 6556, 6559*, *Standley & J. Valerio 44429, 44520*; H. Granadilla, between R. Las Cañas and R. S. José, *Dodge & Thomas 6719*.

COCCOCARPIA *albida* Dodge, sp. nov.

Type: Costa Rica, Limón, Hamburg, *Dodge & Nevermann 7401*.

Thallus albidus, isidiosus, lobis rotundatis, flabelliformibus, 10 mm. latis, zonatus, inferne albus rhizinis albidis, apicibus rhizinarum nigricantibus, thallus 120–130 μ crassitudine, cortex 15 μ , hyphis longitudinalibus septatis, 5–6 μ diametro; zona scytonematica ad 40 μ crassitudine, filamentis laxis implexis, medulla 40–60 μ crassitudine hyphis periclinalibus compactis; cortex inferior hyphis hyalinis dense compactis; rhizinis albidis fasciculatis penicillatis.

Thallus mineral gray or lighter, densely isidiose in the center, lobes rounded, flabelliform as in *C. pellita* v. *parmelioides*, 10 mm. broad, more or less zonate, below white with white rhizinae, the latter sometimes tipped brownish black; thallus 120–130 μ thick, cortex 15 μ thick, of longitudinal septate hyphae 5–6 μ in diameter; algal zone 40 μ thick, of loosely tangled filaments of *Scytonema*, medulla 40–60 μ thick, of compact periclinal hyphae; the lower cortex of hyaline hyphae more or less agglutinated; rhizinae white, fasciculate, and penicillate.

The lower surface resembles that of *Sticta* sp. quite closely, but cyphellae are absent and the structure is typical of *Coccocarpia*. Perhaps it is an albino variety of *C. cronia* var. *isidiophylla*. It has much broader lobes than *C. dominguensis*.

Limón: Hamburg, 20–30 m., *Dodge & Nevermann 7401*.

COCCOCARPIA *ELEGANS* Müll. Arg., *Flora* **64**: 507. 1881.

Type: Brasil, São Paulo, Apiahy, *Puiggari*.

No hypothallus, thallus terre-verte, small, linear, dichotomous (rarely trichotomous at the ultimate branches), larger laciniae 0.1–0.2 mm. broad, ultimate branches much narrower, dull and smooth above, white with white rhizinae below, thallus 80–85 μ thick, upper cortex 8–12 μ thick, decomposed, apparently of slender longitudinal hyphae; algal layer about 40 μ thick, irregular, of loosely woven fungus hyphae supporting short irregular chains of angular to subspherical cells 8–12 μ in diameter, medulla not well differentiated from the algal layer but of very loosely

woven slender hyphae; lower cortex 10–15 μ thick of closely woven hyaline, longitudinal hyphae, the rhizinae 40–50 μ in diameter, large fascicles of hyaline hyphae. Apothecia immarginate, 0.1–0.5 mm. in diameter, chestnut, with long fascicles of hyphae forming stiff bristles about the margin, with stipe about 200 μ in diameter and 40–50 μ tall; no amphithecium; parathecium 60 μ thick, of thick-walled hyphae forming pseudo-parenchyma; thecium 60 μ tall; paraphyses slender, filiform, not enlarged at the tips; asci clavate, 4–6 μ in diameter, immature.

The above description is based upon material from Brasil, Rio de Janeiro, *Glaziov 18071*, determined by Müller Argau, who also reports it from Puntarenas, Boruca, 560 m., *Tonduz 5462*. As this is a small epiphyllous species, a large thallus being only 1 cm. in diameter, it is quite possible that it has been overlooked as my epiphyllous material has not yet been examined carefully.